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Airports and the airline industry are key components of the national economy, in part, because air transportation shapes the spatial hierarchy of metropolitan economies. However, it is less well understood how various measures of airport activity might affect or correlate to economic, geographic, and social characteristics of a given metropolitan area. Consequently, this paper analyzes how conventional indicators of airport activity (i.e., enplanements per capita, flight departures per capita, and market originations per capita) might vary spatially and whether the same set of predictor variables are responsible for this variance. Using data from the Bureau of Transportation Statistics, Department of Labor, and the Census Bureau, the regression models for the airport activity variables indicate that the traffic shadow effect and per capita income are the only two predictor variables common in the three models. Conversely, airline-hub status was only significant in the enplanements per capita and the flight departures per capita models. Mega-regions (e.g., New York City, Washington D.C.) underperform on all three measures of airport activity despite their dominance in absolute terms, while tourist destinations (e.g., Las Vegas, Honolulu) tend to over-perform. The overall contribution of this paper is to highlight how different measures of metropolitan area airport activity might yield different spatial and predictive outcomes. Finding answers to this set of questions is crucial to better understand which airport activity measure best captures the geography of the United States air transportation market and which metropolitan area characteristics are key predictor variables in this determination.

AIR TRANSPORTATION BY METROPOLITAN AREA:

DIFFERENT MEASURES OF

AIRPORT ACTIVITY

YIELDS

by

Michael Brian McCarthy

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Approved by

____

Committee Chair

This work is dedicated to my family who inspired, encouraged, and enabled me to complete this work. Without their continuous help I would never have complete this endeavor. Thanks for everything, and I love you.

APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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Date of Acceptance by Committee

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Date of Final Oral Examination

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A&A	administrative and auxiliary
ACS	American Community Survey
AL	Alabama
AK	Alaska
AR	Arkansas
AZ	Arizona
B	unstandardized coefficient
BTS	Bureau of Transportation Statistics
CA	California
CO	Colorado
CSA	combined statistical area
CT	Connecticut
D.C.	District of Columbia
DE	Delaware
DOC	Department of Commerce
FAA	Federal Aviation Administration
FIRE	finance, insurance, and real estate
FL	Florida
GA	Georgia
HI	Hawaii
IA	Iowa
ID	Idaho
IL	Illinois
IN	Indiana
IT	information technology
KS	Kansas
KY	Kentucky
L	large
LA	Louisiana
M	medium
MA	Massachusetts
MA	metropolitan area
MD	Maryland
ME	Maine
MI	Michigan
MN	Minnesota
MO	Missouri
MS	Mississippi
MSA	Metropolitan Statistical Area
MT	Montana
NAICS	North American Industrial Classification System
NC	North Carolina
NE	Nebraska
NH	New Hampshire
NJ	New Jersey
NM	New Mexico
NY	New York
O&D	origination and destination
OH	Ohio
OK	Oklahoma
OR	Oregon
PA	Pennsylvania
PSMA	Professional, Scientific, Managerial, and Administrative
PST	Professional, Scientific and Technology
PUMS	Public Use Microdata Samples
RI	Rhode Island
S	Small
SC	South Carolina
SD	South Dakota
t	t-statistic
TN	Tennessee
TX	Texas
UK	United Kingdom
U.S.	United States
USCB	United States Census Bureau
UT	Utah
VA	Virginia
VIF	variance inflation factor
VT	Vermont
WA	Washington
WI	Wisconsin
WV	West Virginia

CHAPTER I

INTRODUCTION

Air transportation can provide fast, efficient travel that facilitates face-to-face business interactions and encourages the movement of high-value, low-bulk, time-sensitive goods between metropolitan areas. As a result, airports are now perceived as crucial economic drivers of metropolitan economies and an important element in sustaining competitive advantage among metropolitan areas (Irwin and Kasarda, 1991; Goetz, 1992; Ivy *et al.*, 1995; Button *et al.*, 1999; Debbage and Delk, 2001; Gorlorwulu, 2002; Brueckner, 2003; Nunn, 2004; Liu *et al.*, 2006; Alkaabi and Debbage, 2007; Green, 2007).

Button *et al.* (1999) and Green (2007) used airport activity statistics to argue that metropolitan areas (MAs) that have a robust technology and producer services based economies should have higher airport activity rates than those metropolitan areas that retain disproportionately large goods-based economies. Irwin and Kasarda (1991) and Ivy *et al.* (1995) used different airport activity statistics and found that metropolitan areas with elevated levels of airport activity (e.g., passenger boardings, passenger market originations, flight departures) tend to be more successful in attracting and retaining new, innovative industries thus bolstering the metropolitan economy. However it is less well understood, in detail, how various measures of airport activity might affect or correlate to various economic, geographic, and social characteristics of a given metropolitan area.

This thesis attempts to unravel how conventional indicators of airport activity (i.e., passenger enplanements, passenger market originations, and flight departures per capita) might vary spatially and whether or not the same set of predictor variables are responsible for this variance. It will be argued in this thesis that the different measures of airport activity will be best explained by slightly different sets of predictor variables. It is hypothesized that each dependent variable will share a set of key predictor variables but each dependent variable will also have specific predictor variables that differ. It is expected that each dependent variable model will include an independent variable that measures the overall affluence levels of a MA in some way, such as per capita income or unemployment rates. Likewise, the three dependent variables will share an independent variable that captures workforce characteristics, like total MA population with a bachelor degree or total employed in the professional, scientific, management, and administrative (PSMA) sector. By contrast, it is expected that airline-hub status will only be a predictor variable for enplanements per capita because of the nature of this particular airport activity statistic: MAs with an airline hub generally have higher enplanements than non-hub MAs.

The overall contribution of this thesis to the existing literature is to bring an elevated sensitivity to how different measures of metropolitan area airport connectivity might yield different spatial and predictive outcomes by contrasting three measures of airport yield. Getting rigorous answers to this set of questions is crucial if we are to better understand which airport activity measure best captures the geography of the U.S. air transportation market and which MA characteristics are key predictor variables in this determination.

CHAPTER II

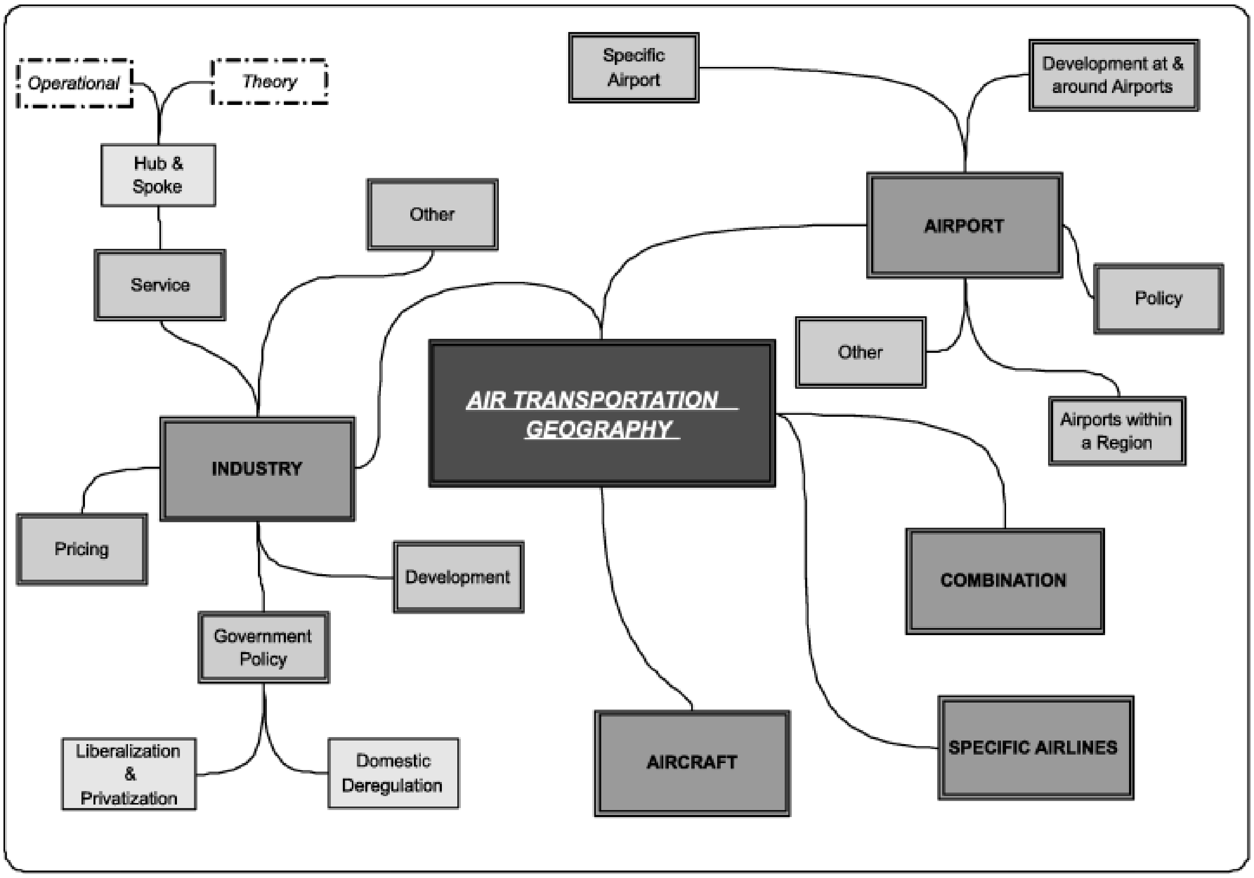
REVIEW OF THE LITERATURE

The existing literature focused on the geography of airport-related development and connectivity tended to utilize a wide variety of measures when defining airport activity. That said, a fairly robust literature has developed focused on how air transportation and airport related development might shape metropolitan economies (Goetz, 1992; Button *et al.,* 1999; Debbage and Delk, 2001; Gorlorwulu, 2002; Brueckner, 2003; Nunn, 2004; Liu *et al.,* 2006; Alkaabi and Debbage, 2007; Green, 2007). Enplanements and enplanements per capita are commonly used in the literature to measure airport activity rates while others utilize ticket or market originations although this data is based on a 10% sample and does not capture total passenger movements. Other scholars examined other airport activity statistics such as international enplanements to assess connectivity levels to international markets (Vowles and Mertens, 2005), while others have studied origin-destination data (Irwin and Kasarda, 1991). Still others have examined "nodality" by identifying the number of direct service flights between MAs (Ivy *et al.*, 1995). This literature review will first look at the history of air transportation scholarship and the post-deregulation airline industry followed by an analysis of research that focused on airport activity rates by MA.

Vowles (2006) provides a very helpful contextual overview of the scholarly work done on air transportation by a geographer. Vowles assessed the growing multitude of themes (i.e., topics) covered by transportation geographers. He concluded that an air transportation geographer tend to publish in one of five topic areas including research in airports, airlines, aircraft, industry issues, or some combination of these four previous themes (page 14-15). In

Vowles's conceptual diagram (Figure 2) it would appear this thesis is rooted in the research focused on airports and their role in its region.

Figure 2: Themes of geographic analysis in air transportation



Source: Vowles (2006).

Although Vowles (2006) help contextualize the research proposed in this thesis, **Goetz and Vowles** (2009) provide some historical context by analyzing the broad-based impacts of airline deregulation on the airline industry. They suggest that airline deregulation is now viewed as both part of the neoliberal policy agenda of the time and the *laissez-faire* approach to most economic matters. They found that the positive results of airline deregulation were lower fares, increased passenger traffic, and more flights; however, they also pointed out that not all aspects of a deregulated airline industry were positive. They argued that while deregulation forced certain airline efficiencies, they all but required hub-and-spoke networks that created non-competitive oligopolies in some markets, reduced service to small/medium airports (requiring government programs to forestall this), and created “predatory” pricing behavior that made the financial conditions of the airlines highly volatile. They also suggested that the current global economic crisis that, in part, resulted from the deregulation of the financial sector had its roots in “deregulation as a universal economic policy panacea” (page 252) that essentially began with airline deregulation.

Goetz and Vowles (2009) go on to suggest that airline deregulation enabled substantial growth of the industry (nearly tripling total enplaned passengers over 30 years) while keeping costs reasonable for the consumer. However, this was at a cost, according to Goetz and Vowles, including a high rate of mergers/acquisitions or liquidations, instability of employment for airline workers, the emergence of oligopolies at “fortress hubs,” and poor service with high fares to certain areas. In the end, Goetz and Vowles suggested that the airline industry needs more oversight. The public interest is not served and there is a need to refocus on some government oversight (i.e., regulation) of the airline industry.

Research more directly connected to the specific research hypothesis proposed in this thesis includes **Goetz** (1992) who specifically examined “the relationship between air passenger transportation [per capita] and the growth of [population and employment in] U.S. urban places from 1950 to 1987” (page 218). Goetz partly filled the void in the previous literature that existed between macro scale historical studies that focused on the general relationships that existed between transportation and urban systems as well as the micro scale studies that focused on the immediate and direct impacts of specific airport projects on local economies. Goetz derived an "air passenger per capita index" by dividing each MA's total enplaned air passengers by the MA's population. He then used population and total employment data (rather than specific industrial sector data) for the 50 largest air passenger markets to better explain how enplaned air passengers per capita shaped the economic geography of these 50 metropolitan areas.

Goetz (1992) attempted to understand the direction of the relationship between air traffic and urban growth by correlating both previous and subsequent population and employment growth rates with air transportation utilization rates. Goetz found a positive and statistically significant relationship existed between enplaned passengers per capita and population growth by metropolitan area although the strength of this relationship varied from decade to decade (it was strongest in the 1960's). Goetz argued that the relationship between air transportation and urban growth was "bi-directional" – enplaned air passenger volume can lead to population growth but the population size of the metropolitan area can also trigger enplanement growth.

Goetz (1992) also found that MAs that have high air passenger yields tended to be located in the South and Southwest (i.e., the "Sunbelt") periphery while the Northeast and Midwest (i.e., the "Frostbelt") core tended to generate lower air passenger yields. He asserts that air transportation in the South and Southwest is more important because these regions were not integrated as well into the U.S. rail or roadway networks (the temporal coverage of Goetz's study includes years prior to and after the completion of much of the Eisenhower Interstate System).

Although Goetz (1992) clearly indicated that a positive relationship existed between air transportation and population/employment growth, he also pointed out that the relationship was diminishing in strength. He suggested, "Arguments for building new airports or increasing airport capacity *solely* on the basis of promoting future growth may lack conclusive empirical foundation" (page 235). Goetz recommended that the criteria for expanding an airport's capacity should be either passenger demand or the development of a "strategic hub location." Goetz concluded that airport expansion to meet passenger demand or to develop an airline hub is well advised but airport expansion for other reasons is not generally the best use of capital.

Like Goetz (1992), **Irwin and Kasarda** (1991) examined air passenger demand and its link to the regional economy over time, but they use a different airport activity statistic than Goetz. Irwin and Kasarda used origination-destination (O&D) data to measure the volume of air passengers between MAs. That said, the O&D data used is very similar to passenger enplanements data although it also indicates broad measures of connectivity between airports. Irwin and Kasarda argued that "the rise of air transportation between 1950 and 1980 substantially reduced frictional constraints to long-distance economic interaction, thereby creating new locational advantages for metropolitan areas" (page 524). Focused on metropolitan areas, they examined how changes in airport-based connectivity (they call it "centrality") in the national network might influence the employment growth rate collectively for all industries, and then separately for both manufacturing industries and producer services.

Irwin and Kasarda (1991) compiled data for the largest 104 metropolitan areas in 1950; they used the Census Bureau's Public Use Microdata Samples (PUMS) from 1950 and 1990. PUMS uses the location of a person's residence rather than their work; Irwin and Kasarda assumed that relatively few people will commute outside the metropolitan area to a nonmetropolitan area to work. Another difficulty the data presents is the changing definition of what constitutes a metropolitan area (MA) and the expansion of MAs over time. Irwin and Kasarda assume that, "Changes in metropolitan area boundaries due to growth simply reflect spatial development and are not a problem of validity" (page 527).

Irwin and Kasarda (1991) use airline passenger O&D data from 1950 and 1980 to construct a metropolitan area (MA) exchange matrix that measures the "origin-destination exchanges among metropolitan areas," where all airports within a MA are aggregated (page 528). The exchange matrix was then standardized by MA population (yielding a per capita rate) and used to calculate a connectivity index for each MA (they called it "network centrality" meaning the MA's direct or indirect access to the entire airline network). Irwin and Kasarda found that airline connectivity had a significantly positive effect on employment change. They also argued that a MA's percent change in airline connectivity was the overriding factor stimulating growth in producer services employment.

In a finding that seems counter intuitive, Irwin and Kasarda (1991) found no support for the common assertion that producer services thrive in densely populated, older metropolitan areas (page 532). Their results indicated that the coefficients for MA population density and age of housing stock are negative for each industry set (i.e., producer services, manufacturing, and all the industries in the study) indicating an inverse relationship (page 530). This seemingly contrary finding could be rationalized if Irwin and Kasarda looked at the per capita nature of their data. The independent variables of density and age of home stock seem to act as surrogate variables representing the Northeast that has a low per capita airport activity rate due to the large population base used to normalize the airport activity statistic of each MA.

Another surprising result was that Irwin and Kasarda (1991) found a negative correlation existed between higher rates of producer services specialization and airline centrality as measured by the MA exchange matrix. Irwin and Kasarda explained that this is more an effect of the rise of other smaller airports (e.g., Dallas, Charlotte, Atlanta, etc.) that were not dominant in 1950 rather than major metropolitan areas like New York and Chicago losing position (i.e., centrality) in the national airline network.

Irwin and Kasarda (1991) also determined that a causal relationship existed where "changes in air transportation have altered the competitive advantages of metropolitan areas and not the reverse" (page 533). This finding shows how positive (negative) changes in a MA's position (i.e., centrality) can yield a positive (negative) effect for the MA's economic development.

Irwin and Kasarda (1991) also found that the population shift from the "Frostbelt" to the "Sunbelt" during the 30 year period of the study led to a similar shift in the nation's airline network (i.e., airlines followed the population shifts). In general, but specifically for the "Sunbelt," metropolitan areas had increased accessibility to air travel due to airline deregulation.

By contrast with other scholars who use airport activity statistics to quantitatively define the relationship between a MA and other aspects of its economy, **Ivy, Fik, and Malecki** (1995) analyzed the changing connectivity, they call it "nodality," to assess how MAs keep and/or draw new businesses. Ivy, Fik, and Malecki particularly examined how air service connectivity levels contribute to attracting and retaining companies. They focused specifically on a subset of producer services – administrative and auxiliary employment – while earlier work had focused on total population or other assessments of industrial composition. Ivy *et al.* analyzed the average yearly rate of change in air service connectivity for the period 1978 to 1988 (the first decade after airline deregulation) and linked this to the average yearly rate of change in total administrative and auxiliary (A&A) employment over the same time period. Like Irwin and Kasarda's earlier airline "connectivity matrix," Ivey *et al.* uses a measure of connectivity they call the "nodality index" - simply a measure of a MA's connection to other MAs **-** to determine the direct linkages from one MA to another. A one (1) was assigned to describe the relationship between MAs that have direct service connections (i.e., a direct flight) and a zero (0) was assigned between MAs that do not have direct service. A nodality index was calculated for each year (1978-1988) and the change in a MA's nodality from year to year indicated the absolute change in connectivity rank between 1978 and 1988.

Ivey et al. (1995) showed that, on average, changes in administrative and auxiliary employment led to changes in connectivity, "[a] strong and positive relationship [exists] between the average annual changes in connectivity and professional employment levels" (page 170). Although there was statistical evidence to suggest that MAs classified as post-deregulation hubs (e.g., Charlotte) had connectivity changes that tended to lead (rather than lag) A&A employment. This was consistent with the authors' survey data on the importance of air service connectivity on a company's decision regarding where to locate to access skilled professional, white-collar labor. Ivy *et al.* suggested that a two-way relationship existed between air service connectivity and A&A employment levels. "[A]ir service connectivity serves as both a stimulus (supply-related) and response (demand-related) variable" (page 174). This supports earlier findings by Goetz (1992) regarding the "bi-directional" nature of a MA's airport activity rate and broader economic development trends.

Liu, Debbage, and Blackburn (2006) built on these earlier works by utilizing a logistic regression model to determine the most influential MA traits that likely predict future major air markets. They specifically "examine the spatial distribution of major air passenger markets in 2000 by [metropolitan areas (MA)]" by using location, socio-economic, and demographic data plus the weather conditions of each MA.

Liu *et al.* (2006) used air passenger enplanements as their airport activity statistic to assess why some metropolitan areas operate as a major air traffic markets while other MAs remain smaller (i.e., minor) markets. Liu *et al.* found a natural break among MAs existed at the 0.75% passenger enplanement level where MA's with more than 0.75% of total U.S. enplanements are considered major passenger markets and those below are considered minor markets.

Liu *et al.* (2006) identified 37 major and 108 minor markets, although Honolulu was excluded as a geographic outlier leaving just 36 major markets in the U.S; they only analyzed MAs with a population of at least 350,000. They found that, generally, air traffic patterns mimic population geography and the exceptions to this rule are largely explained by the composition of the workforce. Some of their findings included: If a MA increases its population by 100,000 people then the odds of that MA becoming a major market increased by 49%. Additionally they found that if the percentage of the workforce in professional, scientific, and technical (PST) increased by 1%, then the odds of the MA becoming a major air traffic market increased by 194%. Likewise, they found that if the percentage of the workforce in tourism increased by 1% then the odds the MA will become a major market will increase by 45%.

A key variable in the research of Liu *et al.* (2006) was distance to a major market (i.e., the traffic shadow). If a minor market could, somehow, change its relative geographic proximity to a major air traffic market then it would have 279% odds of becoming a major market; this was by far the largest odds percentage value. This finding shows that a minor air traffic market that is geographically close to a major air traffic market is unlikely to become a major air traffic market itself because neither the major air traffic market generating the shadow will become a minor market (there is a certain path-dependency that keeps major markets from slipping to minor markets) nor can the minor market physically move itself outside the traffic shadow. This finding shows the strength of this independent variable, traffic shadow, and the difficulties a minor air traffic market has becoming a major air traffic market.

Another interesting finding from Liu *et al.* (2006) is that the more sunny days a MA has yields a negative impact on the MA's odds of becoming a major market. This seems counterintuitive but Liu *et al.* found that this result was due to the sunny-day variable acting as a surrogate for densely populated MAs located in the north and northeast which have typically have major air passenger markets.

Debbage and Delk (2001) expanded the earlier research of Ivy *et al.* (1995) and set the foundation for Liu *et al.* (2006) by investigating the links between air passenger volume and administrative and auxiliary (A&A) employment levels. Ivy *et al.* (1995) used only airport flight connectivity but Debbage and Delk used FAA passenger enplanement data for the top 50 urban-airport complexes in the United States from 1973 to 1996 as their primary airport activity statistic. They found that "[A] strong and predictable linear relationship exists between air passenger volume and administrative and auxiliary employment over time" (page 165). A significant outlier in 1996 was Las Vegas which had significant passenger enplanements but relatively low A&A employment. Debbage and Delk attributed this to the large size of the tourist industry in Las Vegas which attracted an unusually large number of tourist (i.e., leisure) air passengers.

Overall, Debbage and Delk (2001) found that "[s]tatistically significant links exist between air transportation and economic development" (page 166) particularly in sectors that stimulate higher propensities to fly (e.g., administrative and auxiliary employment). They argue that there is considerable evidence to suggest that "air transportation services can directly influence employment levels [in administrative and auxiliary industries]" (page 167).

Debbage and Delk's (2001) study began in 1973 which is prior to deregulation of the airline industry. In this pre-deregulation period the top five MAs had a disproportionately large share of air passenger traffic, however, in 1996 (post-deregulation) the top five MAs had lost some market share. This happened when the top 50 MAs overall market share rose from 80% in 1973 to 87% in 1996. This phenomenon is explained by the larger volumes of enplaned passengers using medium sized airports that turned into major post-deregulation airline hubs (e.g., Atlanta, Dallas, Denver, and Los Angeles).

Debbage and Delk (2001) found several MAs worth investigating further because they bucked the trend. In 1973 (pre-deregulation) the trend between A&A and passenger enplanements was less clear. For example, both Pittsburgh and Detroit had high A&A employment (both in the top five of the 50 MAs studied) but passenger enplanements were not in the top ten. Debbage and Delk explained this by showing that these MAs are more heavily engaged in single-sector industries (i.e., auto and steel industries, respectively) that are less dependent on air travel than other "footloose" industries. By 1983, Pittsburgh experienced a decline in A&A workers that corresponded to the decline of the local steel industry; during this time a rise in passenger enplanements occurred attributed mostly to the development of a U.S. Airways hub.

Debbage and Delk (2001) also indentified Atlanta as an outlier; in 1973 it had rather high passenger enplanements compared to its employment levels for A&A. This was partly a result of the airline hub operations by Eastern and Delta Airlines which resulted in many passengers moving through Atlanta's airport but fewer market originating passengers.

Continuing with the study of the relationship between enplanements and A&A employment, **Debbage** (1999) examined the airports and major cities of North and South Carolina to show how air transportation can influence local economies by evaluating the "interconnectedness" of airport operations, the employment composition of the urban cores (specifically the administrative and auxiliary sector), and its links to regional/national airline strategies. Administrative and auxiliary (A&A, i.e., professional workers) sector data and aviation activity statistics were collected for 1973, 1983, and 1995 representing a temporal coverage both before and after airline deregulation. Debbage only used the counties that were considered the urban core of the metropolitan areas in North and South Carolina rather than larger metropolitan area. Debbage also used total annual enplanements as the aviation activity statistic throughout the study (un-normalized by the population).

Debbage (1999) found that the cities with the highest percentage of workers in the A&A sector had the highest enplanements. He also argued that the Charlotte U.S. Airways fortress hub cast a traffic shadow over neighboring urban cities and, arguably, the entire Carolinas region. Debbage did not use traffic shadow as a independent variable, but rather as an explanation of the performance of various airports in the study. Of the smaller airports in the study, the major tourist destination of Myrtle Beach proved the exception to the general downward trend; of all the airports in the study it is the only one, besides the fortress hub in Charlotte, that grew market share from 1973 to 1995. Myrtle Beach, as a tourist destination, has a substantial enplanement growth while other areas of comparable population stagnated or declined.

Other scholars examined different measures of a MA economy and the connections to air transportation. **Gorlorwulu** (2002) "investigates the effects of changes in the level of air transportation activity on local economic development by focusing on the link between airport activity and regional labor productivity in metropolitan statistical areas in the U.S. for the period 1990-1998” (page 10). He examined passenger enplanement levels for all 295 metropolitan statistical areas (MSAs) in the U.S., regardless if they had a FAA hub or not.

Gorlorwulu (2002) used passenger enplanements per capita for 1990 as well as the natural log of passenger enplanements for the same year to assess MSA airport activity rates. He built a multiple regression model for the natural log of enplanements, then used the same independent variables selected and applied them to a separate multiple regression using enplanements per capita for 1990 as the dependent variable. He concludes that the enplanements per capita model is weaker (i.e., coefficients with insignificant p-values) than the natural log of enplanements even though he did not allow the so-called “weaker” model to select the best independent variables. It is expected that a multiple regression model built for one dependent variable (i.e., enplanements per capita) would yield independent variables that, when used in a separate model for a different dependent variable (i.e., natural log of enplanements) would generate a “weaker” model.

Despite Gorlorwulu’s (2002) finding regarding enplanement per capita rates for MSAs, his analysis of airport hubs, based on the natural log of enplanements regression model, found the FAA definition of large, medium, and small hubs (entered as dummy variables) had a significant and positive correlation to the dependent variable; meaning each of the three types of hubs significantly influenced enplanement levels over MSAs that do not have a large, medium, or small FAA hub.

To assess the education level of each MSA, Gorlorwulu (2002) used the percent of the MA population that has at least two years of college. To capture sector production he used the percent share of earnings for goods production, producer services, and consumer services. A dummy variable is used to represent MSAs in the southern region, however this variable was not significant in the model.

Gorlorwulu (2002) held that "[t]he use of air transport services by the producer sector will lead to a strong link between the regional specialization in producer services and airport activity" (page 63). This is supported by earlier findings from Ivey *et al.* (1995), and Debbage and Delk (2001). Gorlorwulu also found that "airport activity influences regional labor productivity . . . a large hub airport has [larger] disproportional effect on regional labor productivity than medium and small hubs" (page 80).

Instead of measuring the impact of airport activity rates on a MA's economy, **Button, Lall, and Trice** (1999) examined the benefits of an airline hub for a MA. They specifically examined "the benefits that local urban areas [and passengers] enjoy as the result of a major airline selecting the MA as the fulcrum point for its hub-and-spoke services" (page 53). They contrasted MAs with post deregulation airline hubs with MAs without an airline hub yet had comparable passenger enplanements. Button *et al.* suggested that the benefits for passengers in or around a MA with an airline hub included:

- overall lower fares (due to economies of scale),
- greater choice of airline services,
- more direct flights,
- more frequent flights,
- more opportunities for same day return flights,
- greater likelihood of international flights, and
- links to other hubs.

Button *et al.* (1999) also indicated that some of the negative aspects of an airline hub in a MA included the potential for an oligopoly to develop in certain markets which can lead carriers to charge higher fares due to a lack of competition.

Button *et al.* (1999) indicated that high-tech workers tend to fly 1.6 times more than workers in traditional industries (a source for this estimate is not cited). They suggested that an airline hub in a MA is a stimulus for high-tech employment. Their modeling suggested that an airline hub in a MA can increase the region's high-tech employment base by 12,000 jobs. Button *et al.* also indicated that airlines create hubs and these hubs create a competitive advantage that can result in a rise in high-tech employment. Button *et al.* "inferred that [airline] hub airport cities accrue greater economic development than non-hub airport cities," even when compared to MAs with similar total passenger enplanement levels (page 58).

Alkaabi and Debbage (2007) updated the literature by looking at the potential linkages that existed between total passenger enplanements and professional, scientific, and technical (PST) services as well as the high-technology sector, a more specific subset of administrative and auxiliary employment. They especially focused on employment patterns and the number of establishments. They determined that a strong positive linear relationship existed between enplaned passengers and PST/high-tech establishments with a few significant outliers (Huntsville, Albuquerque, and Melbourne). Alkaabi and Debbage found that gateway airline hubs (e.g., Los Angeles and New York) generated a higher level of PST employment than connecting airline hubs (e.g., Atlanta, Chicago, and Dallas).

Alkaabi and Debbage (2007) also found that the relationship between percent high-tech and enplaned passengers was weaker than for PST although they explained this by noting that the proportion of the labor market attributable to high-tech was much smaller than for PST and is, thus, less likely to shape the MA demand for air transport.

Alkaabi and Debbage (2007) used the FAA definition of a hub that is based on total passenger enplanements by percent of total U.S. enplaned passengers (large hub: greater than 1% of total US enplanements; medium hub: 0.25 – 0.99%, and small hubs 0.05 – 0.24%). However, Alkaabi and Debbage subdivided the large hubs into three subclasses using natural breaks in the data for a more robust analysis. This was an attempt to move beyond the simple FAA definition to understand the differences within and between the largest hubs in the U.S. These three new subclasses of airport size better denote the actual differences among airports defined as a large hub although it still does not capture the subtle difference between a FAA defined hub and an airline hub (i.e., part of a hub-and-spoke network).

Nunn (2004) utilized passenger enplanements, flight departures, enplaned cargo and mail volumes to evaluate the economic benefit of the massive airport infrastructure investment at Indianapolis International Airport for its new Midfield Terminal. It is generally understood that a MA needs access to air transportation services for national and global economic success. However, it is less well understood to what extent (if any) MAs can garner a competitive advantage by significant investment in aviation infrastructure to entice airlines and other air services to the MA.

Nunn (2004) used comparison MAs to determine what MA leaders might expect from aviation investment programs. Nunn identified four "peer" metropolitan statistical areas (MSA) that are similar to Indianapolis in size and general geographic location in the Midwest (termed "competitor" MSAs - Cincinnati, Cleveland, Columbus, Kansas City) and four other MSAs that exemplify emerging "knowledge-based" or "new economies" that still match Indianapolis in size (termed “exemplar” MSAs - Austin, Nashville, Raleigh, Sacramento). To compare the airport activity rates of all nine MA airports, Nunn normalized the 1990-2001 annual averages for total aircraft departures, enplaned passengers, non-stop freight-tons enplaned, and non-stop mail-tons enplaned by the population of the MSA yielding a per capita measure.

Nunn (2004) found that the “competitor” MSAs had significantly higher aviation investments per capita than the “exemplar” MSAs ($13.67 compared to $9.85, respectively); and the exemplar MSAs had half the total average aviation infrastructure investment of the competitor MSAs. The exemplar MSAs experienced similar aircraft departures per capita rates as the competitors MSAs but the exemplars MSAs generated more enplaned passengers per capita. However, the competitor MSAs had much higher freight and mail-tons per capita rates. Nunn concluded that “[a]n influx of people, rather than cargo, might therefore be better for a region” (page 8) because a “new economy” is based on people, services, and knowledge capital rather than physical production and/or logistics. The investment in the Indianapolis aviation infrastructure improved the movement of freight/mail but did not generate parallel success in enplaned passengers per capita. He suggested that freight/mail enplanement rates had a weaker effect on a local economy compared to passengers.

Nunn (2004) then calculated how much each of the airport activity measures cost in dollars of aviation infrastructure investment. The exemplar MSAs spent, on average, $95 less for an aircraft departure ($266 versus $361), $1.74 less for an enplaned passenger ($3.37 versus $5.11), and about the same for the freight and mail-tons enplaned. He suggested that the competitor MSAs are “buying” higher volumes of aviation outputs via aviation infrastructure investment just to remain competitive. In the end, Nunn suggested that aviation infrastructure investment is just one of many factors crucial to economic success. The exemplar MAs had low aviation infrastructure investment but still were considered a new economy success story.

Vowles and Mertens (2005) used international enplanements as their only airport activity statistic, a considerable difference from most of the earlier work on air transportation. Vowles and Mertens focused only on one city that aggressively marketed its airport to enable economic growth and to overcome a significant air traffic shadow problem. The research utilized a case study approach of Sanford International Airport, located outside Orlando, Florida. They argued that Sanford airport grew its international enplanements by marketing itself very effectively to UK charter airlines by offering quick, cheap airport access to Central Florida's tourist region. They suggested that Sanford's Airport's marketing efforts coincided with a major gate expansion from five to twelve gates and that a public/private partnership enabled this expansion; the partnership focused on the development of this specific international niche.

However, no clear economic indices are used to calculate the changing economic development conditions in Sanford, although Vowles and Mertens (2005) do submit that a "single international route can mean between $130 million and $300 million annually for a region's economy" (page 36). The research failed to acknowledge that Sanford and Orlando are part of the same functional region as well as the same metropolitan area so any growth at Sanford is potentially offset by a reduction in international enplanements at Orlando's airport, therefore potentially no net growth for the metropolitan area.

However, Vowles and Mertens (2005) do illustrate how a much smaller airport within 100 miles of a major airport can develop strategies to overcome the negative impacts of a traffic shadow effect. An airport can only do this if it focuses on the following principles:

1) "The airports' customers are the airlines, not the passengers."

2) "All airports are in competition with one another."
3) "Small and medium size airports need to decide whether they can be a hub or whether they need to be a feeder route into other hubs, and then pursue the chosen strategy relentlessly."
4) "Market access is more important than the facilities the airport provides" (page 36).

While Vowles and Merten (2005) examined the role of niche marketing and public-private partnerships in helping airports overcome the traffic shadow effect of another larger airport, **Fuellhart** (2007) analyzed the traffic shadow (i.e., airport market leakage) based on passenger choice in a case study of the Harrisburg International Airport and Baltimore International Airport.

Fuellhart (2007) looked at the consumer behavior of air passengers. There seems to be a dichotomy between business travelers and personal air passengers; business passengers generally are concerned more with convenience while air passengers traveling for a personal reason are generally concerned with price. The list of variables a business and personal air passenger considers is long, subject to randomness and taste (e.g., airport access times, type of aircraft, socio-economic considerations, number of passengers traveling together, consumer perception/experience, among others) (page 232).

Fuellhart (2007), like most scholars, consider airports within 100 miles (a one to two hour drive) as competitors (other scholars sometimes use 150 miles but this is the exception). Fuellhart's regression to determine airport substitution used four independent variables, two of which are indicators of fare. The two fare independent variables had the highest influence (p-value: less than 0.01) suggesting that the cost for the consumer is the primary determinate for airport substitution.

Fuellhart (2007) concluded by looking at means for an airport to overcome a traffic shadow. He focuses mostly on an advertising campaign that focuses on the airports strengths (e.g., convenience, low fare for certain routes, etc.). Examples of such advertising for Harrisburg International include signs that read, “98% less annoying . . . The Antidote to the big airport. Harrisburg International Airport” or “My, the gestures you learn on the drive to [Baltimore International Airport]” (page 241). There is evidence that this type of advertising works.

Clearly the literature focused that uses airport activity statistics as a basis for analysis is well developed, but perhaps the most influential research efforts for this thesis were Brueckner (2003) and Green (2007).

Brueckner (2003) rigorously evaluated the direct economic benefits provided by MA airports based on an analysis of variation in passenger enplanement data where enplanement data was not normalized by the MA population. Brueckner found that air passenger demand is positively correlated with airline hubs, major leisure markets (measured by just two leisure destinations: Las Vegas and Orlando), total population, and the proportion of college graduates. However, enplanements are negatively correlated with the traffic shadow effect (meaning small and medium sized airports within 150 miles of a major airport/hub had fewer enplanements).

Brueckner (2003) also found that airline traffic demand is not affected by a MA’s distribution of young or old, average heating degree days for the metro area, being located in a right-to-work state (or not), and personal or corporate income tax rates. Brueckner also found that the link between a MA’s air passenger enplanements and economic development are contemporaneous (rather than with a lead or a lag) or, again, as Goetz (1992) would say, “bi-directional.”

Brueckner (2003) did not feel comfortable using hub status as a variable because he really wanted to use variables "that effect airline traffic without being strongly correlated with employment" (page 1457). Airport hub status is considered strongly correlated to both employment and airline traffic so Brueckner does not use hub status as an independent variable. Instead, a "centrality" variable is used to indicate an airport's suitability as a domestic hub by virtue of its geographic location relative to the center of the U.S. Brueckner developed a regression model with centrality (acting as a proxy for hub status) and compared these results with a separate regression model that used the airline hub status variable. The findings indicate that centrality is a poor proxy for airline hub status; the model shows that centrality has an insignificant coefficient. The numerous exceptions to the assumptions of the centrality variable (e.g., Newark, Miami, Washington-Dulles, Philadelphia, and San Francisco, among others) seem to prove that centrality is a poor proxy for airline hub status out of hand, but Brueckner's regression models provide the statistical proof.

In the end, Brueckner (2003) found that "a 10 percent increase in passenger enplanements in a metro area leads approximately to a 1 [one] percent increase in employment in service-related industries . . . [However] has no effect on manufacturing or other goods related employment" (page 1467). Brueckner applies this to a case study of the proposed expansion of Chicago's O'Hare airport and determined that service related jobs would grow by 185,000, if the expansion increased enplanements by 50 percent.

The other influential research was by **Green** (2007). Much like Nunn (2004), Green also used multiple measures of airport activity rates including passenger originations and enplanements. Green used both variables to assess how the new variable of passenger originations performed relative to passenger enplanements. Green utilized enplanements per capita and originations per capita as dependent variables in separate multiple regressions to see if these measures of airport activity could help predict population change and employment growth (or decline). Green found that air passenger enplanements per capita and originations per capita in 1990 had a similar and "substantial" impact on population and job growth from 1990 to 2000. Green found that a one standard-deviation increase in enplanements per capita generated an 8% increase in the following decade's population and job growth. Other independent variables are proven to be statistically significant including several human capital variables (e.g., percent of the population that earned a high school diploma or college degree by age 25), the presence of a state capital within the MA, and if the MA is warm, "warmer places grow faster than cold places" (page 105). Green also found that an airport with an airline hub can trigger population growth that is 9% to 16% faster and employment growth that is 8.4% to 13.2% faster than non-hub cities.

Green (2007) attempted to find causality between airport growth and economic development. To control for economic development causing airport activity he looks at airport activity and then only subsequent economic development to see if the earlier airport activity in fact caused the later economic development. This technique enables a better understanding of causality but Green acknowledges that this does not necessarily solve the problem. Green found that the previous-decade population growth and airport runway capacity explained airport activity. He also found that airports within 100 miles of a large hub have less activity resulting from a traffic shadow; however, airports within 100 miles of a medium hub have a less perceived traffic shadow effect or no effect at all. Green also finds that the industrial makeup (i.e., percent of MA employment in manufacturing and the finance, insurance, and real estate (FIRE) sectors) and the presence of a state capital "do not seem to influence passenger activity" (page 105).

Interestingly enough, while Green (2007) found enplanements were a strong indicator of a MA's population and employment growth, the same did not apply to the geography of enplaned cargo (which supports the findings of Nunn, 2004). The two largest cargo hubs, Memphis with FedEx and Louisville with UPS, were not considered "fast-growth" MAs by Green. Workers in knowledge-based industries (as indicated by enplaned passengers) push the MA's economy, not cargo which generally requires large levels or automation and warehousing while generating little employment.

The literature review focuses on works that provide context for this work or use an airport activity statistic as a basis for the research. The following research is an extension of the work done by Green (2007) and Brueckner (2003); these two scholars did the most robust regression analysis using airport activity statistics as the dependent variables. This research will build on their work by contrasting three airport activity statistics for a better understanding of the different spatial, economic, and social predictor variables that explain the variance for each airport activity statistic.

CHAPTER III

RESEARCH DESIGN

There is a large body of research regarding the relationships of air transportation to economic, social, and geographic characteristics of areas; however there is little research that systematically compares the different airport activity measures by metropolitan area. Furthermore, metropolitan area policymakers are always looking at ways to promote competitive advantage and various economic growth strategies. Growing a MA's air connectivity level is often considered a way to foster such an advantage (Brueckner, 2003; Green, 2007).

As mentioned earlier, this thesis is designed to identify how the conventional indicators of airport activity (i.e., per capita measures of passenger enplanements, market originations, and flight departures) might vary spatially and if the chosen predictor variables are consistent for each of these airport activity indicators. The independent variables are selected based on the earlier scholarly literature, although additional independent variables are added as a means to further understand the differences between the airport activity indicators. The overall contribution of this thesis to existing literature is to bring an elevated sensitivity to how different measures of connectivity might yield different spatial and predictive outcomes.

The most commonly used airport activity variable is passenger enplanements, sometimes called passenger boardings. The FAA defines an enplaned passenger as a revenue passenger boarding an aircraft. Enplanements indicate the total passengers moved by a MA's airport(s) in terms of departures, but it does not capture arriving passengers. Also, the enplanement data does not effectively distinguish between passengers that are just beginning a flight (a market origination) versus connecting passengers that may be departing on an additional flight segment (a transfer).

The enplanement variable is the most widely used airport activity statistic. Ivy *et al.* (1995), Debbage (1999), Button *et al.* (1999), Debbage and Delk (2001), Liu *et al.* (2006), and Alkaabi and Debbage (2007) all use total enplanements as their aviation activity statistics while Irwin and Kasarda (1991), Goetz (1992), Gorlorwulu (2002), Brueckner (2003), Nunn (2004), and Green (2007) used enplanements per capita to generate a yield for each geographic area studied.

The second airport activity variable used in this thesis is market originations. Originations, unlike enplanements, count only those passengers that begin (originate) from a particular MA; subsequent flight transfers are not counted. For example, a round trip ticket generates two market originations, one market origination for the home market and one market origination for the destination market because of the return trip from the destination. This variable can be interpreted as the actual trip generation rate attributable directly to a MA since it excludes the large number of transfers that result from MAs that host airline hub(s) (e.g., Dallas, Charlotte, Atlanta, etc.).

Market origination data is based on a 10% sample of all tickets from each airport studied. Like the first dependent variable, the market originations sample is divided by the total population to generate a yield or rate that allows comparison among different sized MAs. Because of the complications that arise from using sample data, only Green (2007) was found to use this type of measure so far.

The third variable used in this thesis to capture airport activity levels is the number of flight departures performed. Such an indicator emphasizes flight connectivity by assessing the volume of aircraft movements departing a MA, regardless of the total passengers moved. Flight frequency is considered a key measure of the competitive status of a MA although using flight departures can be limiting since it cannot distinguish between a small, regional jet and a larger wide-body jet. However, there are several measures of connectivity used in the literature like Irwin and Kasarda (1991) and Button *et al.* (1999). Like the two proceeding dependent variables, flight departures performed per capita is normalized by the metropolitan area population to allow standardized yield comparisons among markets regardless of absolute size. Flight departures performed per capita, or simply flight departures per capita, captures many of the characteristics found in other derived connectivity indices. The data source for all the airport activity statistics is the Bureau of Transportation Statistic (BTS), the agency that reports the Federal Aviation Administration (FAA) data.

The central areal unit to be used in this thesis is the metropolitan area (MA). The MA appropriately captures the entirety of the labor pool surrounding any given airport since it is defined based on work-trip commuting behavior. A combined statistical areas (CSA) is used as the unit for a MA unless a CSA is not defined for a particular MA, otherwise the metropolitan statistical area (MSA) is used to define the MA. The geographic extent of the CSAs and MSAs used in this thesis are based on the 2006 Office of Management and Budget definitions.

To compare MAs of different population sizes, each airport activity variable is divided by the MA population to generate a yield or productivity measure. The per capita approach normalizes each variable to help highlight which MA has higher (lower) than “normal” rates of enplanements, originations, and flight departures. Irwin and Kasarda (1991), Goetz (1992), Gorlorwulu (2002), Brueckner (2003), Nunn (2004), and Green (2007) all use airport activity variables normalized by population.

The MA's included in this thesis hosted either a large, medium, or small hub in 2006 as defined by the Federal Aviation Administration (FAA) (Table 3.1); the resulting 104 MAs represent nearly 95% of all domestic airline traffic in the U.S. in 2006 (Appendix A). FAA defined hubs located in areas outside a defined metropolitan statistical area or combined statistical area are excluded (Appendix B). It should be noted that the FAA definition of a hub is simply based on the percentage of total US airline traffic at each airport (Table A) and is not considered equivalent to an airline-based definition of a hub (i.e., part of a hub-and-spoke network).

Table 3.1: Federal Aviation Administration Hub definitions

Large Hub	1% or More of Total Air Traffic in U.S.
Medium Hub	At least 0.25% but less than 1% of Total Air Traffic in U.S.
Small Hub	At least 0.05% but less than .025% of Total Air Traffic in U.S.
Non Hub (not used)	Less than 0.05% of Total Air Traffic in U.S.

Source: Federal Aviation Administration, 2006

It should also be noted that some of the larger MAs have multiple airports (e.g., New York, Los Angeles) in which case the multiple airports are aggregated by MA for each airport activity statistic (i.e., enplanements, originations, and flight departures)(Appendix C). A multiple regression model will be developed where each airport activity per capita yield acts as the dependent variable relative to the independent variables listed below to determine the key similarities and differences in the way the three airport activity indicators vary spatially.

The independent variables used in this research are economic, social, and geographic indicators for the 104 MAs in the study. The data for the independent variables come from several sources but all are standardized by 2006 definition for the MSA or CSA, except where noted (Table 3.2). The American Community Survey (ACS) 2005-2007, 3-year estimates are used because they are more accurate than the one year estimates and the 2006 definition was used for the geographic extent of each CSA/MSA while the 2005 CSA/MSA definitions were used for the single year, 2006 ACS data. The independent variables are listed here in no particular order.

<u>Traffic Shadow Effect (proximity to a large hub):</u> There are several methods used to measure this impact. Brueckner (2003) and Green (2007) use dummy variables to show MAs that are within 150 or 100 miles of a large airport, respectively, while Liu measures the actual distance to the nearest major market. Fuellhart (2006) considered MAs with airports competitors if they are within 100 miles of each other. The dummy variable method will be used because it is more common in the literature. For this study, small and medium FAA hub MAs are considered in a traffic shadow of a MA with a large FAA hub if the geographic centers of the MAs are within 100 miles or they share a contiguous border (data source: author's calculations).

<u>Airline Hub:</u> This variable is used by Irwin and Kasarda (1991), Ivy *et al.* (1995), Button *et al.* (1999); Brueckner (2003), and Green (2007) to show how MAs with an airline hub have a competitive advantage over those that do not. For this research a dummy variable is used: one (1) if a MA has at least one airline hub and zero (0) for MAs that have no airline hub. It is critical to see the advantages an airline hub has on MA performance (definition and data source: Standard & Poor's Industry Surveys: Airlines, 2006).

<u>Population:</u> Irwin and Kasarda (1991), Button *et al.* (1999), Brueckner (2003), Liu *et al.* (2006), and Green (2007) each use total population as a measure of the size of each MA. For this

Table 3.2: Independent Variables with Data Source

	Variable	Data Source
1	Traffic Shadow Effect	Author's Calculation
2	Right to Work State	U.S. Department of Labor, Wage and Hour Division*
3	Airline Hub in MA	Standard & Poor's Industry Surveys: Airlines, 2006
4	Population	U.S. Census Bureau (USCB), 2006
5	Travel Time to Work, Average	USCB, 2005-2007 American Community Survey (ACS) 3 Year Estimates
6	Per Capita Income	USCB, 2005-2007 ACS 3 Year Estimates
7	Unemployment, Percentage of Workforce**	USCB, 2005-2007 ACS 3 Year Estimates
8	Information Technology Sector, Percentage of Workforce**	USCB, 2005-2007 ACS 3 Year Estimates
9	Information Technology Sector, Total	USCB, 2005-2007 ACS 3 Year Estimates
10	Finance, Insurance, and Real Estate Sector, Percentage of Workforce**	USCB, 2005-2007 ACS 3 Year Estimates
11	Finance, Insurance, and Real Estate (FIRE) Sector, Total	USCB, 2005-2007 ACS 3 Year Estimates
12	Professional, Scientific, Management, and Administrative (PSMA) Sector, Percentage of Workforce**	USCB, 2005-2007 ACS 3 Year Estimates
13	Professional, Scientific, Management, and Administrative (PSMA) Sector, Total	USCB, 2005-2007 ACS 3 Year Estimates
14	Population Growth	USCB 2004 and 2006
15	Accommodation Employees (NAICS 721), Total	USCB, County Business Patterns, 2006, NAICS 721 ***
16	Accommodation Employees, Percentage of Workforce (NAICS 721)**	USCB, County Business Patterns, 2006, NAICS 721 ***
17	Accommodation Establishments (NAICS 721)	USCB, County Business Patterns, 2006, NAICS 721 ***
18	International Passenger Arrivals	Department of Commerce (DOC), International Trade Administration, Manufacturing & Services, Office of Travel & Tourism Industries
19	International Passenger Departures	DOC, International Trade Administration, Manufacturing & Services, Office of Travel & Tourism Industries
20	Median Age of Housing Stock	USCB, 2005-2007 ACS 3 Year Estimates
21	Bachelor Degree	USCB, 2005-2007 ACS 3 Year Estimates
22	Graduate/Professional School	USCB, 2005-2007 ACS 3 Year Estimates

* Washington D.C. is not considered a right to work MA; only Virginia has right to work laws while the District of Columbia and Maryland do not.

** Workforce is a measure of population over the age of 16 in the labor force.

*** Micropolitans that are part of the CSA are not included in the MA for this variable.

work, population is the key variable used to normalize the dependent variables to generate a yield measure (definition and data source: U.S. Census, 2006).

Travel Time to Work, Average: This variable is a surrogate for highly agglomerated MAs. These agglomerated MAs are so large that significant externalities could exist, like long commute times caused by and causing congestion. Green (2007) uses this variable to see at what point a city is too agglomerated and has a negative effect on air connectivity. The total travel to work time for the MA is divided by the total workforce - total workforce measures the population over the age of 16 in the labor force (definition and data source: U.S. Census, American Community Survey (ACS), 2005-2007 3-Year Estimates).

Per Capita Income: Income is the sum of all the wages, salaries, transfer payments, profits, interests and dividend payments, rents, and other forms of earnings. This all encompassing number is then normalized by the total MA population. Liu *et al.* (2006) uses per capita income to see if more affluent areas have a greater propensity to fly. The American Community Survey 2005-2007 3-Year Estimates use per capita income in the past 12 months, reported in 2007 inflation-adjusted dollars (definition and data source: U.S. Census, ACS, 2005-2007 3-Year Estimates).

Unemployment Rate: Liu *et al.* (2006) uses MA unemployment rate as a general measure of a MA's economic strength; low unemployment equals a strong MA economy. It is assumed that MAs with large unemployment levels will have a lower propensity to fly (definition and data source: U.S. Census, ACS, 2005-2007 3-Year Estimates).

Information Technology (IT) Sector: The IT sector has evolved in the literature from simple broad definitions like producer services, to administrative and auxiliary, the high-tech sector, and finally to the IT sector. The total employees in the IT sector is used as an independent variable as well as the IT sector as a percentage of the total workforce as a separate independent variable. It is assumed that a MA with more workers in the IT sector will have elevated airport activity rates per capita (definition and data source: U.S. Census, ACS, 2005-2007 3-Year Estimates)

Finance, Insurance, and Real Estate (FIRE) Sector: This variable has evolved in the literature from simple classifications of producer services by Irwin and Kasarda (1991), to Debbage and Delk (2001) who use the more specific, yet still broadly defined administrative and auxiliary sector, and finally to Green's (2007) more specific FIRE sector. The total employees in the FIRE sector is used as an independent variable as well as the FIRE sector as a percentage of the total workforce as a separate independent variable to control for MA size. It is argued that MAs with higher volumes/percentages of workers in the FIRE sector will have a higher propensity to fly (definition and data source: U.S. Census, ACS, 2005-2007 3-Year Estimates).

Professional, Scientific, Management, Administrative, and Waste Management Services (PSMA) Sector: Like the IT and FIRE sectors above, the PSMA sector has evolved in the literature from simple broad definitions like producer services, to administrative and auxiliary, and finally to the PSMA sector. The PSMA sector is very similar to the professional, scientific, and technical (PST) variable used by Liu *et al.* (2006) and Alkaabi and Debbage (2007). The total employees in the PSMA sector is used as an independent variable as well as the PSMA sector as a percentage of the total workforce as a separate independent variable to control for MA size. It is assumed that a MA with more workers in the PSMA sector will have elevated airport activity rates per capita. The inclusion of waste management in this variable is due to the categories assigned by the U.S. Census (definition and data source: U.S. Census, ACS, 2005-2007 3-Year Estimates)

Population Growth: Green (2007) looked extensively at population growth as a predictor variable. Population growth was found to be negative for some MAs. The change in MA population is measured by the difference from 2004 to 2006 divided by the 2004 MA population (definition and data source: U.S. Census, population data 2004 and 2006, author's calculations).

Right to Work State: It is argued that states that have laws that limit unions, generally called right-to-work laws, are considered "business friendly" and, therefore, attract more businesses. Business-friendly MAs are expected to have higher airport activity. The U.S. Department of Labor has identified those states that are considered right-to-work states despite the variation in laws and constitutions that enable the right-to-work status. It is hoped this variable will be a surrogate for the Sunbelt (more right-to-work states are generally in the South) but it failed to be significant in Brueckner's 2003 work and Green's 2007 work (definition and data source: U.S. Department of Labor, Wage and Hour Division).

Total Accommodation Employees: It is well established in the literature that certain tourist destinations have much higher trip generation rates than would otherwise be expected for a MA of that size or sector make up. Brueckner (2003) and Liu *et al.* (2006) found that major tourist destinations are strongly correlated to enplanement levels. Both total and percentage of the workforce measures are used as an independent variable in the three models (definition and data source: U.S. Census, County Business Patterns, 2006, NAICS 721).[1]

Accommodation Establishments: This variable is slightly different than the previous measure of a tourist destination; it measures the magnitude of a MAs tourist draw by the total number of accommodation establishments. The subtle difference between employment and

[1] CSAs are formed by summing the MSAs; both MSA and CSAs are without the data for the surrounding micropolitans. For MSAs that reported a range, the average of the range was used.

establishments in the accommodation sector could be considerable in the models so both are used (definition and data source: U.S. Census, County Business Patterns, 2006, NAICS 721).[2]

International Arrivals/Departures: There is little research that looks at a MA's economic performance based on the total number of international arrivals or departures. Vowles and Mertens (2005) use this variable in a case study of a small airport in the air traffic shadow of a major tourist destination competitor. This variable should also highlight the role of international gateway MAs like New York or Miami (definition and data source: Department of Commerce (DOC), International Trade Administration, Manufacturing & Services, Office of Travel & Tourism Industries using Department of Homeland Security data).

Median Age of Housing Stock: Green (2007) and Irwin and Kasarda (1991) use this variable. Green found it a strong surrogate for the North and Northeast regions of the U.S. that generally have old housing stock while the Sunbelt and West ordinarily has newer housing stock. Irwin and Kasarda seemed to over look the proxy nature of this variable (definition and data source: U.S. Census, ACS, 2005-2007 3-Year Estimates).

Bachelor Degree: This variable looks at the educational composition of the MA. Irwin and Kasarda (1991), and Green (2007) argue that a populace that is highly educated will have a higher propensity to fly (definition and data source: U.S. Census, ACS, 2005-2007 3-Year Estimates).

Post-Graduate or Professional Degree: This variable, like the bachelor degrees variable above, looks at the education composition of the MA. Higher educated MAs are expected to have more producer services and, therefore, a higher propensity to fly (definition and data source: U.S. Census, ACS, 2005-2007 3-Year Estimates).

[2] CSAs are formed by summing the MSAs; both MSA and CSAs are without the data for the surrounding micropolitans. For MSAs that reported a range, the average of the range was used.

CHAPTER IV

FINDINGS

4.0: Enplanements, Market Originations, and Flight Departures

There are three different measures of airport activity rates used in this thesis, each measuring a different aspect of airline and airport operations. First, enplanements are a measure of revenue passengers boarding an aircraft (i.e., departing passengers). In this sense, enplanements capture connecting (transferring) and originating passengers at any given metropolitan area (MA). Another important measure of airport passenger activity is market originations. Market originations count only those passengers that start their trip at any given MA and do not include connections that may be required to complete an outbound trip, unlike enplanements. Of course roundtrip itineraries generate two market originations; the outbound and return-trip itineraries each generate a market origination because the return trip will have a specific starting point (i.e., market origination) that differs from the outbound market origination.

The third and final indicator of airport activity levels used in this thesis is flight departures. Enplanements and market originations are essentially measures of passenger movements while flight departures are a measure of aircraft movements. A flight departure is defined as “an aircraft take off made at an airport” (FAA). Flight departure data treats each aircraft the same despite varied size and contents (i.e., number of seats, cargo-only, or passenger/cargo). Flight departure data is used here to assess the level of MA connectivity with other MAs. It has been argued that flight connectivity between MAs is a key ingredient in any economic development strategy. Many firms that seek to relocate or expand do so in areas that offers high levels of flight connectivity.

To better understand airport activity rates by MA each dependent variable was divided into the respective MA population for 2006 to standardize the impact of market size and assess overall productivity rates. The end result of this thesis is focused on better understanding the geography of the following three dependent variables:

- Enplanements Per Capita
- Market Originations Per Capita
- Flight Departures Per Capita.

4.1 Enplanements Per Capita

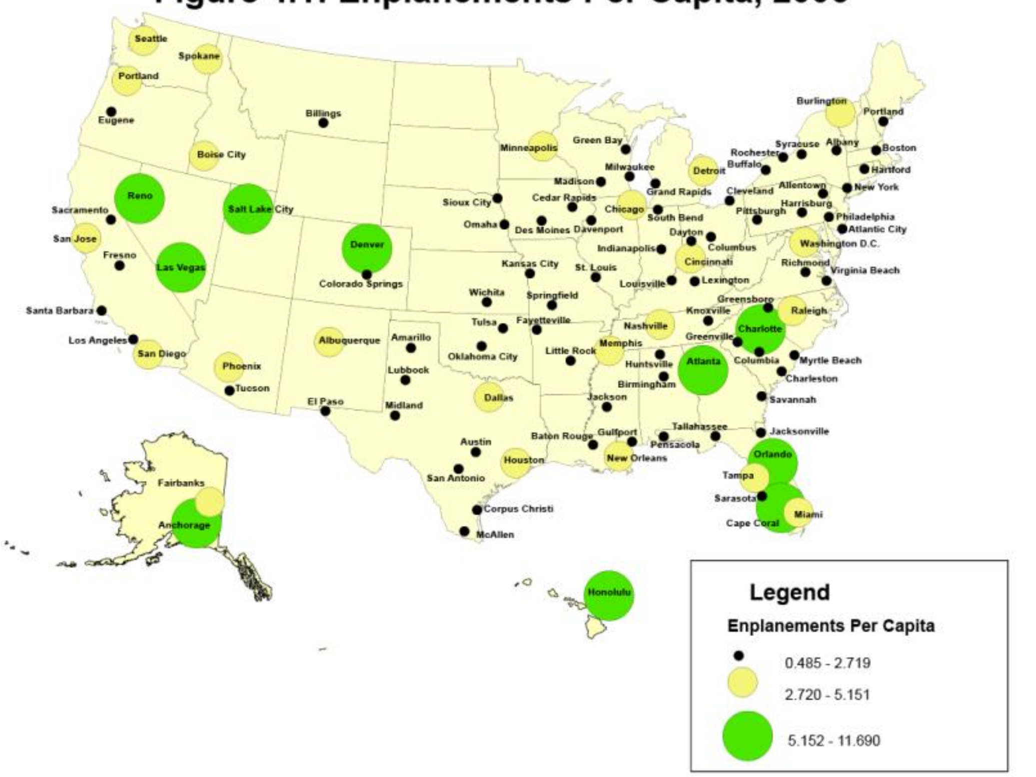
The enplanements per capita for the 104 MAs included in this thesis range from a low of 0.49 for Allentown, PA to a high of 11.69 for Las Vegas, NV (Table 4.1), with a mean for all 104 MAs of 2.65 enplanements per capita. There were 35 MAs that overperformed (exceed the mean) while the other 69 MAs underperformed. Table 4.1 shows the top ten MAs by enplanements per capita for 2006. The map in Figure 4.1 shows the geographic distribution of enplanements per capita for all 104 MAs.

The enplanements per capita rankings illustrate that major tourist destinations tend to dominate the top ten (Table 4.1). The three leading MAs for enplanements per capita included Las Vegas, Honolulu, and Orlando; each of these MAs is a major tourist destination (as measured by workers in the accommodation sector, NAICS 721). Major tourist destinations rank high in this index because of the large number of visitors to these markets (for business or pleasure) and

Table 4.1: Top Ten Metropolitan Areas Ranked by Annual Enplanements Per Capita, 2006

Rank	Metropolitan Area	Enplanements Per Capita	Flight Departures Per Capita	Market Originations Per Capita
1	Las Vegas, NV CSA	11.69	0.114	0.917
2	Honolulu, HI MSA	9.28	0.103	0.634
3	Orlando, FL CSA	7.72	0.075	0.678
4	Denver, CO CSA	7.68	0.097	0.383
5	Atlanta, GA-AL CSA	7.44	0.085	0.241
6	Charlotte, NC-SC CSA	6.70	0.101	0.188
7	Cape Coral, FL MSA	6.40	0.064	0.624
8	Salt Lake City, UT CSA	6.30	0.096	0.315
9	Anchorage, AK MSA	6.10	0.223	0.402
10	Reno, NV CSA	5.40	0.068	0.504

Figure 4.1: Enplanements Per Capita, 2006



the relatively small population of these top-ranked tourist destination MAs. For example, in 2006, Las Vegas had a population of only 1.82 million (i.e., the 31st largest MA of all 104 MAs in the study) compared to an overall mean MA population of 2.04 million. Las Vegas's below-average population size combined with its above average enplanement totals (i.e., ranked 11th for total enplanements) make it the most productive MA in terms of enplanements per capita.

Las Vegas is a national and international tourist destination and is home to eight of the ten largest hotels in the world.[3] Las Vegas is also the largest tourist destination in the U.S. as measured by workers in the accommodation sector (NAICS 721) with over 181,000 workers. Its closest U.S. rival is the near-by Los Angeles MA which had only 81,000 workers in 2006, less than half the number of workers in the accommodation sector of Las Vegas. Las Vegas is not only a national and international tourist destination, but it is also a regional airline hub for Southwest Airlines (not large enough to be a national airline hub according to the Standard and Poor's Industry Survey for Airlines, 2006). Southwest Airlines had 7.6 million (36%) of the 21.1 million total enplanements at Las Vegas airport.[4] The combined roles of Las Vegas as a major tourist destination and airline hub may be key factors contributing to the elevated enplanement per capita levels (Figure 4.1).

The Honolulu MA mimics the Las Vegas dynamic since it also is a major tourist destination with a relatively small total population. The Honolulu MA was only ranked 24th in total enplanements but the MA population was only 909,863 (ranked 57th of the 104 MAs included in this study). In addition, with few exceptions, a plane flight is the only way to get to the island MA from the continental U.S.

[3] http://www.vegastodayandtomorrow.com/largesthotels.htm, Accessed September, 2009.
[4] AAS, 2006, Table 6 page: 462-5.
https://www.bts.gov/pdc/user/products/src/products.xml?p=2708&c=1
Downloaded October 28, 2009

The Orlando MA ranked third in enplanements per capita for reasons similar to those articulated for the Las Vegas and Honolulu MAs. Orlando's population is over 2 million (ranked 26th out of 104 MAs) and therefore has a larger total population than either Las Vegas or Honolulu. Orlando is home to Disney World, among other tourist attractions, and ranked fourth in total number of employees in the accommodation sector (NAICS 721) with 51,000 workers. The end result is Orlando generated a disproportionately high number of enplanements per capita.

Metropolitan areas with medium sized populations that also have major airline hubs make up much of the remaining MAs featured in Table 4.1. These include Denver (United Airlines), Atlanta (Delta Airlines), and Charlotte (U.S. Airways). A good case in point is the Delta Airlines hub in Atlanta which rivals the Chicago MA in total enplanements (40.7 million versus 43.4 million, respectively) even though the Atlanta MA has a population nearly half that of the Chicago MA (5.4 million versus 9.7).

MAs with major airline hubs have a disproportionately high enplanement rate as a result of the high number of connecting (transferring) passengers. Atlanta is the quintessential example of a "fortress hub" where the airline controls a significant number of gates and terminals leaving little room for competition at that airport.[5] Delta with its Delta Connection airline partners[6] account for 30.5 million of 40.8 million enplanements in Atlanta, representing nearly 75% of the total market share.[7] Fortress hubs enable the dominate airline to control prices, prevent market entry, and reduce competition from other carriers. Charlotte is another example of a fortress hub

[5] Goetz, A., T. Vowles. 2009. *The good, the bad, and the ugly: 30 years of US airline deregulation.* Journal of Transport Geography. 17, page 252.
[6] Airlines operating as Delta Connection: Atlantic Southeast Airlines, Comair, Compass Airlines, Chautauqua Airlines, Freedom Airlines, Mesaba Airlines, Pinnacle Airlines, Shuttle America, SkyWest Airlines. Compass and Pinnacle Airlines do not service Atlanta.
[7] Author's calculation based on AAS, 2006, Table 6, pages 284-8. https://www.bts.gov/pdc/user/products/src/products.xml?p=2708&c=1, Downloaded October 28, 2009.

that has significantly more enplanements per capita than its population would otherwise suggest. With affiliate airlines (PSA and Piedmont), US Airways has 11.1 million of the 14.7 annual enplanements and dominates Charlotte's Douglas International Airport with a 75% market share.[8] Denver (featured in Table 4.1) is also considered a fortress hub (United Airlines) following the trend of Atlanta and Charlotte. Salt Lake City was not defined as a major airline hub by the 2006 Standard and Poor's Industry Survey for Airlines but it has a regional airline hub for Delta Airlines and this, in part, accounts for its position in the top ten.

Perhaps, even more illuminating are the MAs not listed in Table 4.1. For example, some of the largest passenger markets in absolute terms –New York, Los Angeles, and Chicago – are absent. Part of the explanation resides with the enormous population base included within the boundaries of each respective CSA. For example, the New York CSA is spread out from Western Connecticut to northern New Jersey with nearly 22 million people. Despite the large total enplanements, the New York, Los Angeles, and Chicago mega regions, among others, underperform by comparison to the less-populated MAs that host airline hubs and/or major tourist destinations because each of these mega-regions have such a large population base.

The map in figure 4.1 clearly shows how MAs that dominate enplanements per capita are either airline hubs locations, tourist destinations, and/or explained by unique local circumstances. The absence of the major MAs in the Northeast is evident; with the exception of the Washington D.C. MA operating at the medium range of enplanements per capita, all the other major MAs in the Northeast tend to underachieve. This map however does not show the unique circumstances that drive the Cape Coral MA into the top ten MAs for enplanements per capita.

[8] Author's calculation based on AAS, 2006. Table 6, pages 517-20. https://www.bts.gov/pdc/user/products/src/products.xml?p=2708&c=1, Downloaded October 28, 2009

The Cape Coral MA appears to be an outlier in Table 4.1. Cape Coral does not have an especially robust professional, scientific, management, and administration (PSMA) sector, information technology (IT) sector, or financial, insurance and real estate (FIRE) sector; PSMA, IT, and FIRE sectors are typically associated with higher trip generation rates than other sectors (Debbage and Delk, 2001). Cape Coral's status as a major leisure destination is also in question because it only ranked 57th in the number of workers in the accommodation sector (NAICS 721). Cape Coral also lacked an airline hub which tended to feature prominently among the MAs featured in Table 4.1. One potential explanation for Cape Coral's high ranking in enplanements per capita is the large population base located outside the Cape Coral MA who use it as their primary airport. The Naples MA is just south of Cape Coral and has only four scheduled flights a week to just one destination, Key West. Moreover, Naples Municipal Airport promotes itself as the "Best Little Airport in the Country" suggesting it is just a small community airport.[9] The lack of airline connectivity in Naples and its close proximity to Cape Coral (Naples is only a 30 minute car trip to Cape Coral's airport) suggests that residents in both MAs utilize Cape Coral's airport. Another reason Cape Coral has a large number of enplanements per capita is the presence of a low cost air carrier (Southwest Airlines).

Cape Coral's high ranking in enplanements per capita may also be explained by the large number of affluent retirees who live in Cape Coral and Naples. The percentage of the population that is over the age of 65 in both Cape Coral and Naples exceeds even the Florida average of 17.6% (U.S. average is 13.0%) with a 25.4 and 24.5% share, respectively. Likewise, the median household income of both Cape Coral ($40,319)[10] and Naples ($48,289)[11] exceeded the State's

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[9] Naples Municipal Airport Homepage: http://www.flynaples.com/ Accessed 28 October, 2009.

[10] US Bureau of Census: Table DP-3. Profile of Selected Economic Characteristics: 2000, Geographic area: Fort Myers-Cape Coral, FL MSA, Page 3. Downloaded September 23, 2009.

average of $38,819 in 2000. It is argued here that affluent retirees have a higher propensity to fly and this may generate disproportionately high enplanement levels. In addition, the Cape Coral MA population was just over 571,000 in 2006 (ranked 74th out of the 104 MAs) so it needs far fewer enplanements than more populated MAs to generate a significant per capita yield.

4.2 Flight Departures Per Capita

Flight departures measure the total aircraft takeoffs performed in a MA and therefore flight departures measure MA to MA connectivity levels. The total flight departures for each MA is divided by the MA population for 2006 resulting in a measure of flight departure productivity. Flight departures per capita, however, do not differentiate plane size (i.e., it treats a 19 seat Beech 1900[12] the same as a fully loaded 747 widebody with 400-500 seats[13]) which means MAs that attract a large number of small commuter jets may rank quite high on a per capita basis even though they are not large air passenger markets in an absolute sense. Flight departures per capita varied from a low of 0.008 in McAllen, TX to a high of 0.250 in Fairbanks, AK with an overall mean of 0.046 flight departures per capita with 33 MAs performing at or above the mean and the remaining 71 MAs underperforming. Table 4.2 shows the top ten MAs by flight departures per capita for 2006. Figure 4.2 shows the geographic distribution of the MAs based on flight departures per capita.

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[11] US Bureau of Census: Table DP-3. Profile of Selected Economic Characteristics: 2000, Geographic area: Naples, FL MSA, Page 3. Downloaded September 23, 2009.

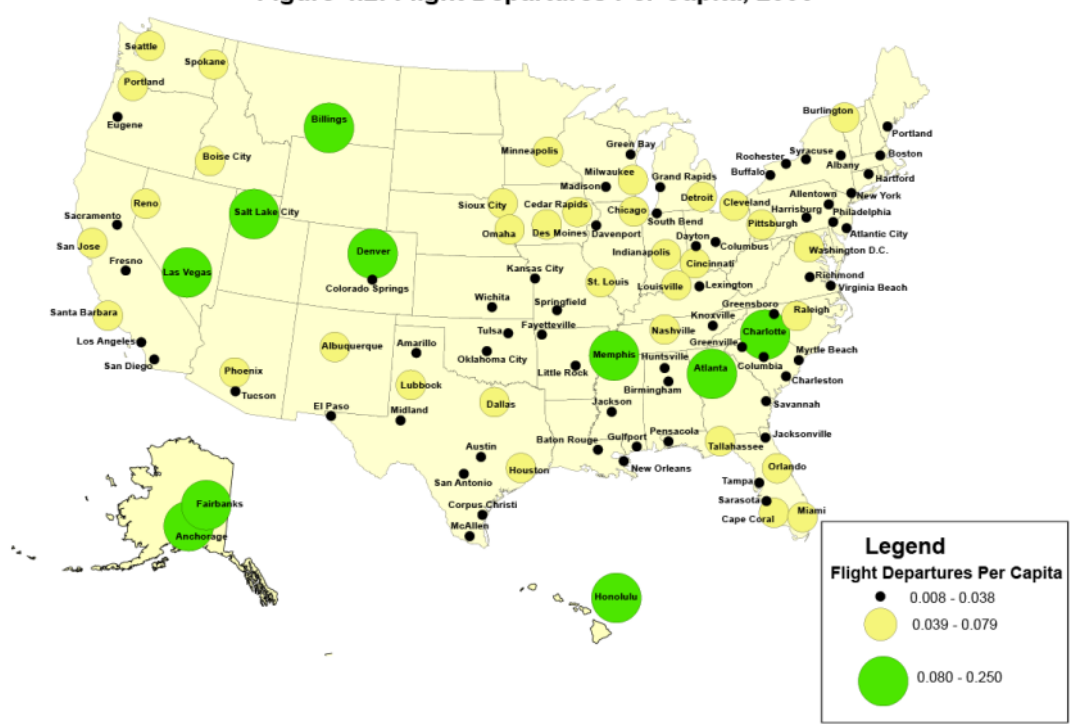
[12] Raytheon Specifications and Performance Beechcraft 1900D Corporate Shuttle: http://www.raytheon.com/businesses/rtnwcm/groups/public/documents/content/rtn_raas_prod_1900dcs_pdf.pdf Accessed January 18, 2010.

[13] Boeing Commercial Airplanes, Fact page: http://www.boeing.com/commercial/747family/747-8_facts.html Accessed January 18, 2010.

Table 4.2: Top Ten Metropolitan Areas Ranked by Annual Flight Departures per Capita, 2006

Rank	Metropolitan Area	Flight Departures Per Capita	Market Originations Per Capita	Enplanements Per Capita
1	Fairbanks, AK MSA	0.250	0.377	4.87
2	Anchorage, AK MSA	0.223	0.402	6.10
3	Memphis, TN-MS-AR MSA	0.131	0.133	4.32
4	Las Vegas, NV CSA	0.114	0.917	11.69
5	Honolulu, HI MSA	0.103	0.634	9.28
6	Charlotte, NC-SC CSA	0.101	0.188	6.70
7	Denver, CO CSA	0.097	0.383	7.68
8	Salt Lake City, UT CSA	0.096	0.315	6.30
9	Atlanta, GA-AL CSA	0.085	0.241	7.44
10	Billings, MT MSA	0.081	0.244	2.72

Figure 4.2: Flight Departures Per Capita, 2006



Seven of the top ten MAs featured in Table 4.2 were also listed in the enplanements per capita rankings of Table 4.1. The two dependent variables are also highly correlated with a Spearman correlation coefficient score of 0.85, significant at the 1% level. This suggests that both enplanements per capita and flight departures per capita are highly correlated for all 104 MAs in the study and may exhibit similar geographies.

Once again, several major tourist destinations generated elevated flight departures per capita including Las Vegas and Honolulu. MAs with large airline hubs in places like Charlotte, Denver, and Atlanta also generated high levels of flight departures per capita. Each airline hub helped its MA overperform in flight departures per capita relative to its position in the MA population hierarchy. Elevated flight departures are linked to airline-hub operations because these hubs, by their very nature, have a high number of departing flights as part of the hub-and-spoke route network.

That said, the two highest ranking MAs in terms of flight departures per capita were both located in Alaska – Fairbanks (0.250) and Anchorage (0.223) – due to Alaska's large expanse and geographic separation from the mainland. However, these two airports have very different operating characteristics. Anchorage has nearly four times the annual flight departures of Fairbanks (80,010 departures versus 21,668, respectively) but Anchorage has a much larger population and subsequently generated a lower flight departure per capita rate. By contrast, Fairbanks services an area that is so remote that it has a "float pond" for small airplanes that must land on water in the summer and a "ski/gravel strip" for the small airplanes that take off for the snow strips typical at small Alaskan towns in winter.[14] In 2006, Fairbanks generated 16,538 small airplane fight departures (less than 50 passengers or small cargo-only) of the 21,668 total

[14] Fairbanks International Airport Brochure, http://www.dot.state.ak.us/faiiap/ Accessed October 1, 2009.

flight departures (75% share) with only 260 long-range and/or wide-body flight departures.[15] By contrast, Anchorage generated 39,100 small plane departures annually (of an annual total of 80,010) which accounted for only 49% of total flight departures.[16] Both Anchorage and Fairbanks, AK are also significant tourist destinations; the two Alaskan MAs ranked 13th and 14th, respectively, for the percentage of the workforce in the accommodation sector (NAICS 721).

Two significant anomalies standout in Table 4.2: Memphis, TN and Billings, MT. Billings has a high per capita rate for flight departures for many of the same reasons as Anchorage and Fairbanks. Billings is the airport service provider for about a 300 miles radius market area around the remote, northern Rocky Mountain region of the U.S. Due to the "thin" air passenger markets in the smaller surrounding cities, passengers "leak" directly to Billings or connect through Billings via small airplanes (like the Cape Coral and Naples example mentioned earlier, the airport activity rate for Billings is boosted by passengers from neighboring municipalities not captured in the MA). Only 1,035 of the 12,041 annual flight departures (8.5%) from Billings were on long-range and/or wide-body aircraft; over half of the flight departures for Billings were conducted on a Beech 1900 or a RJ-200ER that only have 19 and 50 seat max capacities, respectively.[17] The end result is that even though Billings enplanements per capita were the lowest of those listed in Table 4.2, it is still able to generate a high number of flight departures per capita.

By contrast, Memphis is a hub for Northwest Airlines and while it only ranked 17th for enplanements per capita, it ranked 3rd for flight departures per capita. The high rank of Memphis in flight departures per capita is probably attributed to the FedEx air freight super-hub located in

[15] Author's calculation based on Airport Activity Statistics, Table 7 "Aircraft Departures Scheduled, and Performed, by Community, Air Carrier, and Aircraft Type" Page 83-8.
[16] Ibid: Page 27-36.
[17] Ibid: Page 668.

Memphis. In 2006, FedEx had 64,562 flight departures (38% share) from Memphis that were likely cargo only.[18] MAs with comparable numbers of flight departures had nearly three times as many enplanements as Memphis; likewise MAs with comparable enplanements had substantially fewer flight departures. Consequently, Memphis, in this research, really set itself aside as an anomaly.

The similarity of the enplanements per capita map (Figure 4.1) and flight departures per capita map (Figure 4.2) is striking. The flight departures per capita map shows the prominence of hubs (Atlanta, Charlotte, etc.), regional markets with large volume of small-regional flight departures (Billings, Fairbanks), tourist destinations (Las Vegas, Honolulu), and super-cargo hubs (Memphis) while minimizing the MAs in the Northeast and Rustbelt.

4.3 Market Originations per Capita

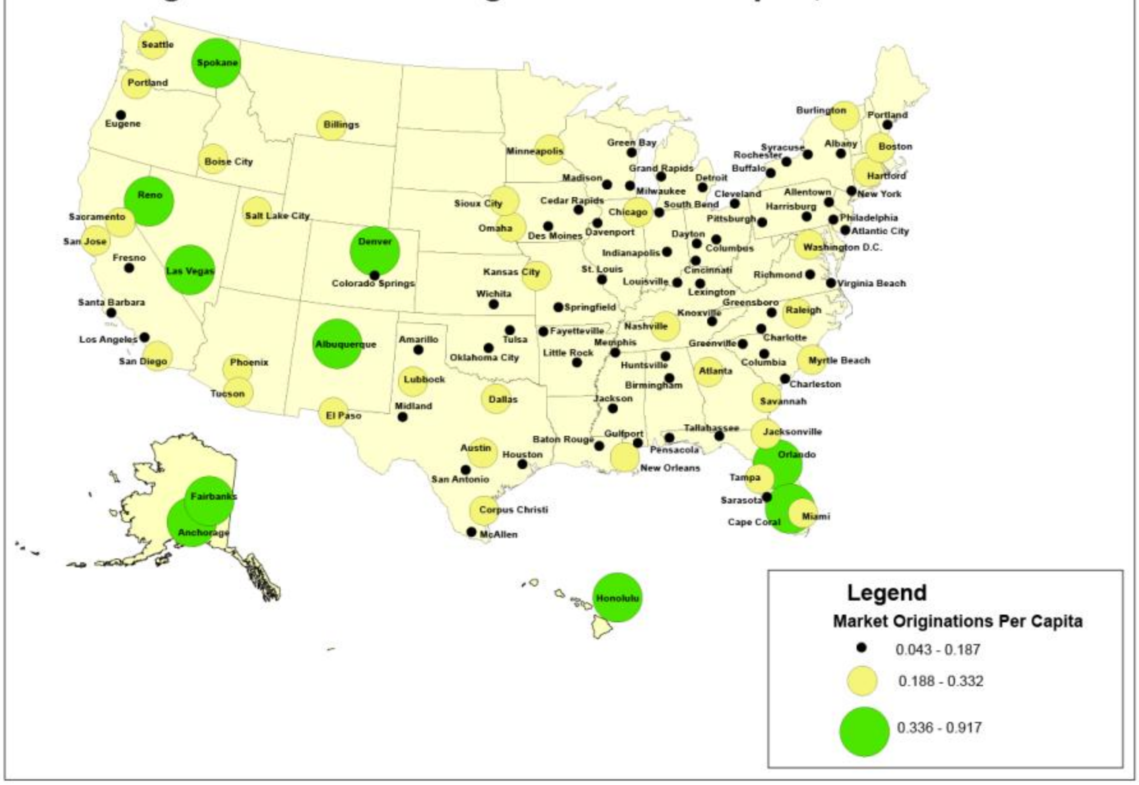
Market originations per capita measures how many passengers start their trip at any given MA. Passengers are considered market originations for a MA only if they first board for the outbound or return leg; subsequent flight transfers are not captured by market originations. The Las Vegas MA tops the market originations per capita rankings with a per capita magnitude measure of 0.917 (Table 4.3). The Allentown, PA metropolitan area is ranked last in market originations per capita with a score of 0.043. The average rate for the MAs was 0.198 with 40 MAs overperforming and 64 underperforming. Figure 4.3 represents the geographic distribution of MAs based on market originations per capita.

[18] Author's calculation based on Airport Activity Statistics, Table 7 "Aircraft Departures Scheduled, and Performed, by Community, Air Carrier, and Aircraft Type" Page 926.

Table 4.3: Top Ten Metropolitan Areas Ranked by Market Originations Per Capita, 2006

Rank	Metropolitan Area	Market Originations Per Capita	Enplanements Per Capita	Flight Departures Per Capita
1	Las Vegas, NV CSA	0.917	11.69	0.114
2	Orlando, FL CSA	0.678	7.72	0.075
3	Honolulu, HI MSA	0.634	9.28	0.103
4	Cape Coral, FL MSA	0.624	6.40	0.064
5	Reno, NV CSA	0.504	5.40	0.068
6	Anchorage, AK MSA	0.402	6.10	0.223
7	Denver, CO CSA	0.383	7.68	0.097
8	Fairbanks, AK MSA	0.377	4.87	0.250
9	Spokane, WA MSA	0.340	3.59	0.059
10	Albuquerque, NM MSA	0.336	3.89	0.057

Figure 4.3: Market Originations Per Capita, 2006



Seven of the MAs listed in Table 4.3 are also featured in the rankings by enplanements per capita (Table 4.1) and five MAs are also listed in flight departures per capita rankings (Table 4.2). Anchorage, Denver, Honolulu, and Las Vegas feature in the top ten for all three rankings of airport activity rates (Tables 4.1, 4.2, and 4.3). The similarity of the three dependent variables for all 104 MAs under study is indicated by the statistically significant correlations between the dependent variables. The Spearman Correlation Coefficient score for market originations per capita and enplanements per capita was 0.90 at the 1% level of significance, further the Spearman correlation coefficient for market originations and flight departures per capita was 0.72 at the 1% level of significance.

A MA's status as a major tourist destination is a significant predictor variable for market originations per capita and this suggests stability in this predictor variable regarding its role in shaping the three dependent variables. Major tourist destinations have a high rate of market originations because once a passenger arrives at the tourist destination via an airplane they usually generate a market origination on the return flight to the home MA. Honolulu, Las Vegas, Orlando, and Reno are featured in Table 4.3 and have high market originations per capita. The relatively small population for each of these major tourist destinations is another reason for the elevated per capita rate.

Table 4.3 has only two airline-hub MAs in the top ten including Denver (United Airlines) and Las Vegas (Southwest Airlines, again not large enough to be a national airline hub according to the Standard and Poor's Industry Survey for Airlines, 2006 but relevant enough to cite). Market originations do not count transfer (connecting) passengers, therefore, MAs with airline hubs are deemphasized in the rankings; this breaks the trend for enplanements per capita and flight departures per capita that had four and five MAs with an airline hub, respectively, featured in their top ten. For example, major hubs like Atlanta and Charlotte underperform regarding market originations per capita since they do not generate the same level of market originations as would otherwise be expected for a MA of their position in the national urban hierarchy.

Given the relative geographic isolation of the two Alaskan MAs, Fairbanks and Anchorage, it is not unexpected that both feature in the top ten regarding market originations per capita list. A passenger traveling from Alaska to any of the contiguous 48 states all but requires a plane trip thus making many of the flights from Anchorage or Fairbanks full of market originations rather than transfer passengers. The two Alaskan MAs receive many market originations from tourists. Additionally, the relatively small total population of Anchorage and Fairbanks requires relatively few market originations to have a high yield by comparison to larger MAs.

Cape Coral is also featured in the top ten for market originations per capita for the same reasons mentioned earlier in the discussion of enplanements per capita. Furthermore, the Cape Coral airport is officially called the Southwest Florida International Airport suggesting it markets itself as the airport for a significant portion of the state and thus serves a regional population that is much larger than the population of the Cape Coral MA.

Two MAs in Table 4.3 are considered anomalies: Spokane and Albuquerque. Spokane's high level of market originations may result from its geographic isolation (like Anchorage and Fairbanks), with only small local competitor airports, the significant presence of a low-cost carrier (Southwest Airlines) providing low airfares, and a considerable number of "snowbirds" that live in the Spokane area but live/work elsewhere for a portion of the year.[19]

[19] Woodward, T. Director of Marketing and Public Relations, Spokane International Airport. Interview on November 25, 2009.

Albuquerque's international airport is considered an origination and destination airport because it does not operate an airline hub, therefore there are nearly no transfers. Albuquerque's market extends well beyond the defined MA to reach Eastern Arizona, Western Texas, and Southern Colorado with only slight market leakage to the El Paso MA. Albuquerque is ranked above average for accommodation employees as a percentage of the workforce (30 of 104) so it has a considerable tourist draw for its size. Another significant factor is that the airline with 50 – 60% of the Albuquerque flights is a low cost carrier – Southwest Airlines (though not considered a national airline hub).[20] The large actual market for Albuquerque International Airport, the tourist draw, and the significant presence of a low-cost carrier all help explain why Albuquerque is ranked in the top ten for market originations per capita.

The map in Figure 4.3 differs significantly from the maps representing the geographic distribution of enplanements per capita (Figure 4.1) and flight departures per capita (Figure 4.2) due mostly to the de-emphasis of MAs with airline hubs. The MAs that dominate Figure 4.3 are tourist destinations or MAs where the actual air traffic market is underbounded by the defined geographic area of the MSA/CSA.

4.4: Regression Analysis

Building a multiple regression model for each of the three dependent variables requires an understanding of the independent variables, their relationships to the other independent variables as well as the three dependent variables. For this research, the model development for each dependent variable (enplanements per capita, flight departures per capita, market originations per

[20] Jiron, D. Public Information Officer, Aviation Department, Albuquerque International Airport. Interview on December 18, 2009.

capita) started with 22 independent variables (see Table 4.4a) mostly based on earlier scholarly work (see Chapter III for full descriptions).

An analysis of the correlation between each dependent variable and each independent variable shows the correlation, relationship (positive/direct or negative/inverse), and the significance of this relationship. These relationships among the independent variables were analyzed for multicollinearity issues. The high level of multicollinearity between certain independent variables and the rationale for removal is explained on a variable, by variable basis below.

The independent variables airline hub status and total metropolitan area (MA) population are correlated at the 0.627 level (p-value <0.0001). Likewise, international arrivals and international departures are correlated at the 0.998 (p-value <0.0001). These two pairings of independent variables are so highly correlated at such a significant level that one independent variable in each pair should be removed from the input variables for the model. In these two situations, the independent variables airline hub status and international arrivals remain in the model while MA population and international departures are removed.

The airline hub status independent variable was chosen over metropolitan area population independent variable for several reasons. First, airline hub status is a key variable when studying airports while population, though important, is less important relatively. Second, MA population was strongly correlated to several other variables that also varied by MA population like travel to work time (MAs with a larger population generally have more traffic due to the prevalence of low-density suburban and exurban commuters to the urban core(s) of the MA) or total accommodation employees (the larger the MA, the more hotels needed to accommodate visitors, conventions, etc.). Travel to work time and total accommodation employees remained in the

Table 4.4a: Independent Variables with Definitions

	Variable	Definition
1	Traffic Shadow Effect	Dummy variable 1 for MA with geographic center within 100 miles or shares border with large hub MA.
2	Right to Work State	Dummy variable 1 if all or most of the MA is in a right to work state*
3	Airline Hub in MA	Dummy variable 1 if MA hosts an airline hub in 2006.
4	Population	MA population in 2006
5	Travel Time to Work, Average	The average travel to work time, in minutes, for members of the MA workforce
6	Per Capita Income	Per Capita Income for the MA, 2006
7	Unemployment, Percentage of Workforce**	Unemployment Rate for the MA, 2006
8	Information Technology (IT) Sector, Percentage of Workforce**	The percent of the workforce in the IT sector.
9	Information Technology, Total	Total IT workers.
10	Finance, Insurance, and Real Estate Sector (FIRE), Percentage of Workforce**	The percent of the workforce in the FIRE sector.
11	Finance, Insurance, and Real Estate (FIRE) Sector, Total	Total FIRE workers.
12	Professional, Scientific, Management, and Administrative (PSMA) Sector, Percentage of Workforce**	The percent of the workforce in the PSMA sector.
13	Professional, Scientific, Management, and Administrative (PSMA) Sector, Total	Total PSMA workers.
14	Population Growth	The change in MA population from 2004 to 2006 divided by the 2004 population
15	Accommodation Employees (NAICS 721)	The total accommodation employees for the MSA or all the MSAs within a CSA ***
16	Accommodation Employees, Percentage of Workforce (NAICS 721)**	The total accommodation employees for the MSA or all the MSAs within a CSA *** divided by total workforce
17	Accommodation Establishments (NAICS 721)	The total accommodation establishments for the MSA/ MSAs within a CSA***
18	International Passenger Arrivals	MA total international passenger arrivals
19	International Passenger Departures	MA total international passenger departures
20	Median Age of Housing Stock	Median age of MA housing stock
21	Bachelor Degree	Total population of the MA over 25 with a four year degree
22	Graduate/Professional School	Total the population of the MA over 25 with a graduate degree or professional degree

* Washington D.C. is not considered a right to work MA; only Virginia has right to work laws while the District of Columbia and Maryland do not.

** Workforce is a measure of population over the age of 16 in the labor force.

*** Micropolitans that are part of the CSA are not included in the MA for this variable.

model and eventually both were selected for one or more the three dependent variable models. Third, MA population it is already part of the model due to the normalization of the dependent variables by the MA population, yielding a per capita measure.

The independent variable international arrivals remains rather than international departures despite their relative magnitudes being similar. The international arrival independent variable is considered better because it measures the draw to rather than the exodus from a MA. This might seem arbitrary but when the two measures of international traffic were used as inputs to make a model for each of the three dependent variables, the international arrivals variable (when selected) was always selected over the independent variable international departures.

The two independent variables for total number of bachelor degrees and graduate degrees in a MA are correlated at 0.6778 level (p-value <0.0001). The bachelor degrees independent variable is used because it also captures those with a graduate degree as well. When both the bachelor and graduate degree variables are entered into a forward or stepwise selection processes, only the bachelor degree independent variable was ever selected indicating it explained more variance. Despite the selection process never using both independent variables, the graduate degree variable is removed because it is so strongly multicollinear with the bachelor degree independent variable.

The existing literature has already studied which industry sectors have a higher propensity to fly and these include: professional, scientific, management, and administrative (PSMA), finance, insurance, and real estate (FIRE), and information technology (IT). A percent share and absolute total measure are used for each sector resulting in six total industry sector independent variables, however all six variables shared high levels of significant correlation. Therefore, to represent all sectors that have a high propensity to fly, only the total PSMA workers independent variable remained as an input for the three regression models because for all the six different measure, it explained the most variance (yielding the highest R-square).

NAICS 721 is used to find the total number of accommodation establishments, employees, and employees per capita. Interestingly, total accommodation establishments and total accommodation employees were strongly correlated (0.873, p-value <0.0001) while the percentage of the workforce in the accommodation sector was not strongly correlated to either. The total accommodation employees variable in this research captures the total mass of a tourist destination because the base unit (a person) is constant while the accommodation-establishment base unit varies (one accommodation establishment could vary from a small "mom-and-pop" motel to a 7,000+ room hotel). The various sizes of establishments is exemplified by Las Vegas that has the most accommodation employees by a factor of two over its nearest rival Los Angeles, but Los Angeles has three times the total accommodation establishments of Las Vegas. The independent variable accommodation establishments is removed from the list of input independent variables while accommodation employees per capita and total accommodation employees are left as inputs for the models.

The list of 22 independent variables is trimmed to 13 (table 4.4b) and these independent variables will be used as inputs for each multiple regression model for the three dependent variables: enplanements per capita, flights departures per capita, and market originations per capita.

To aid in model interpretation, the dependent variables (passenger enplanements, flight departures, and market originations) are each divided by MA population measured in thousands of people for the multiple regression. This manipulation of the standard per capita rate used thus far does not change the coefficients of the models, simply the location of the decimal place of the coefficient. It is hoped that larger coefficients will aid in the understanding of the models by yielding whole numbers for the unstandardized coefficients.

Table 4.4b: 13 Independent Variables Used In Regression Modeling

	Variable	**Measures**
1	Traffic Shadow Effect	1=Yes, 0=No
2	Right to Work State	1=Yes, 0=No
3	Airline Hub in MA	1=Yes, 0=No
4	Travel to Work Time	Raw Value, minutes
5	Per Capita Income	1,000s of Dollars
6	Unemployment, Percentage of the Workforce	Percentage of Workforce
7	Professional, Scientific, Management, and Administrative (PSMA), Total	1,000s of Workers
8	Population Growth	Percent Change, 2004-2006
9	Accommodation Employees (NAICS 721)	1,000s of Workers
10	Accommodation Employees, Percentage of Workforce (NAICS 721)	Percentage of Workforce
11	International Passenger Arrivals	1,000s of Arrivals
12	Median Age of Housing Stock	Years
13	Bachelor Degree	1,000s of People

The model for each of the three dependent variables has undergone the critical analysis of the correlation among all the variables, an analysis of variables (ANOVA), review of the added variable plots (partial regression residual plots), and outliers. Regarding the outliers, comparing the three models made outlier diagnostics less useful because the removal of an outlier MA for one model required its removal from each model making the subsequent models less full-bodied. The final models for each of the three dependent variables exhibit no serious multicollinearity problems among the selected independent variables and met most of the assumptions of linearity, normality, and homogeneity of variance (homoscedasticity). Overall, each model was developed with the goal of achieving the most parsimonious model, to reduce the variation inflation factor (VIF), and lower the condition index.

The unstandardized coefficients enabled an analysis between the various independent variables and the dependent variables within the model. However, to better understand which independent variable had the most influence on the model, the standardized coefficients (Beta) will be used to analyze each model. The Beta value is not compared between models but serves as a comparison of the influence of each independent variable within the model, and the relationship (positive or negative) within the model as well as among the other models. The presence and/or absence of an independent variable in each model is also compared among the three regression models.

4.4.1: Regression Model for Enplanements

The model for enplanements is based on the forward selection, backward elimination, and stepwise selection procedures in SAS version 9.1.3. Each of these procedures resulted in a seven variable model that failed to produce variance inflation factors (VIFs) or a condition index within acceptable ranges. Therefore, with the forward, backward, and stepwise selections as a basis for selecting the preferred model, a more parsimonious five variable model was chosen using the author's knowledge of the subject matter. The resulting model produced a low level of collinearity, high level of fit (Mallows C(p) and mean square error), and high significance levels for each of the independent variables in the model (Appendix D).

The five variable model for enplanements yielded an R-Square of 0.59 (Table 4.4.1). Each independent variable is significant at 0.01 or better and each has a VIF that is less than three.

Table 4.4.1: Multiple Regression Model for Enplanements Per 1,000♦

	Variables	Unstandardized Coefficients		Standardized Coefficients	T	P-Value	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
	Intercept (Constant)	-1,668	1,125		-1.48	0.141		
1	Airline Hub	2,183	473	0.449	4.61	<.0001	0.475	2.106
2	Traffic Shadow Effect	-1,074	339	-0.228	-3.17	0.002	0.871	1.148
3	Per Capita Income	165	46	0.294	3.59	0.001	0.673	1.486
4	PSMA sector, Total Employees	-6	1	-0.567	-5.71	<.0001	0.457	2.188
5	Total Accommodation Employees	42	8	0.471	5.4	<.0001	0.594	1.683

♦For multiple regression models, dependent variables are normalized by MA population measured in thousands of people rather than per capita; this generates larger unstandardized coefficients (B) that should aid in model interpretation.

Enplanements per 1,000 = -1,668 + 2,183 Hub -1,074 Shadow + 165 PCI – 6 PSMA
+ 42 Total Accommodation Employees

A metropolitan area with an airline hub generates 2,183 additional enplaned passengers per 1,000 residents. Conversely, metropolitan areas in a traffic shadow generate 1,074 fewer enplaned passengers per 1,000. MAs that grow per capita income by $1,000 will generate an additional 165 enplaned passengers per 1,000 residents, an additional 1,000 employees in the PSMA sector will generate 6 fewer enplanements per 1,000 residents, and an additional 1,000 accommodation jobs will generate 42 additional enplaned passengers per 1,000 residents.

Further analysis of the predictor variables begins with the one that has the largest standardized coefficient (Beta). For the enplanements per 1,000 model, the total PSMA sector independent variable has the highest absolute value for Beta and yielded an inverse relationship with enplanements normalized by the population. The sign of the relationships between the independent and dependent variables were all as expected, except for the PSMA sector independent variable. It is well established in the literature that MAs that have higher percentages of the workforce in the PSMA sector have a higher propensity to fly because this sector, among others like FIRE, require frequent face-to-face interactions (Debbage and Delk, 2001). The negative Beta for PSMA in the enplanements model might appear to counter this well established relationship, however total employees in PSMA (not percentage of workforce) seem to act as a surrogate for major MAs that generally underperformed when airport activity rates are normalized by the population (e.g., New York City, Los Angeles, Chicago, etc.). These mega MAs tend to dominate the PSMA sector in an absolute sense but underperform when enplanements are normalized due the large absolute population base of each of these mega MAs. Several regression models were run replacing the PSMA independent variable with several other industry-based variables (e.g., total FIRE, FIRE percentage of the workforce, etc.) and the same negative coefficient resulted. This finding is also consistent with the earlier scholarly work of Irwin and Kasarda (1991) who used a per capita airport activity measure and found that the independent variable population density, an indicator of a MA's agglomeration and generally considered a strong indicator of a robust producer services sector, had an inverse relationship with the normalized airport activity measure they used. Likewise, Green (2007) used per capita measures for both passenger enplanements and originations resulting in negative coefficients (indicating an inverse relationship) for the FIRE sector independent variable in some of his regression models. So the negative variable for total PSMA employees should mostly be seen as a variable that indicates how mega MAs underperform due to their large population and a finding that is strongly rooted in the literature.

The accommodation sector workers (NAICS 721) independent variable has the second largest absolute value for Beta. There is a direct relationship between enplanements per 1,000 and total accommodation sector workers, as might be expected. The role of the accommodation sector illustrates the importance that tourist destinations have on a MA's enplanements yield. The presence of Las Vegas, Honolulu, and Orlando (the quintessential U.S. leisure destinations) as the top three MAs on the enplanements per capita rankings (Table 4.1) further exemplifies how the size of the accommodation sector can be a key predictor variable for enplanements normalized by the population.

The third largest Beta for the enplanements per 1,000 model is airline hub status. The direct relationship between hub status and enplanement yield is expected because of the prominence of airline hubs in the top ten rankings for enplanements per capita (Table 4.1). The inclusion of the airline hub status independent variable in the model is also supported in the literature, namely Button *et al.* (1999) who analyzes the benefit an airline hub has on a MA.

The fourth largest Beta is per capita income (PCI). The direct relationship between PCI and the enplanement yield suggests that an elevated enplanement yield is related to an overall measure of affluence. The affluent Cape Coral MA is a example of a small MA with a high PCI, but there are several other examples including Anchorage (PCI rank of 10^{th} and population rank of 90^{th}) and Madison, WI (PCI rank of 9^{th} and population rank of 74^{th}).

The fifth largest absolute value for the standardized coefficient is for the traffic shadow effect. There is a negative relationship between enplanements per 1,000 and the traffic shadow meaning that MAs with a small/medium FAA hub that are within 100 miles, or share a border with a MA with a large FAA hub (e.g., Greensboro is in the traffic shadow of the Charlotte MA) have fewer enplanements than MAs that are not in a traffic shadow. The close proximity to a large FAA hub indicates consumer choice that is generally not available to would-be passengers in MAs that are outside a traffic shadow. This is unfortunate for the MAs in a traffic shadow because MAs may change other characteristics, like raise the PCI, but the geographic proximity is set.

4.4.2: Regression Model for Flights Departures

The backward elimination procedure selected eight variables for the model while the forward and stepwise selection procedures both selected the same six variable model. The eight and six variable models had high VIF values (like the models selected by these procedures for the enplanements dependent variable). By using the six variable models from the forward and stepwise selections as a basis, five of the six independent variables were chosen by the author to develop a more parsimonious model that has the best balance of collinearity, fit, and significance (Appendix D).

The five variable model for flight departures has a R-square of 0.28 (Table 4.4.2). The five independent variables are significant at the 0.02 level or better and each have a low VIF.

Metropolitan areas in a traffic shadow generate 18 fewer flight departures per 1,000 residents. Conversely, metropolitan areas with an airline hub generate 24 additional flight departures per 1,000 residents. An additional year older for the metro's housing stock will generate 1 fewer flight departures per 1,000 and an additional minute in commute time will generate 6 fewer flight departures per 1,000. MAs that grow per capita income by $1,000 will generate an additional 4 flight departures per 1,000 residents of the MA.

Table 4.4.2: Multiple Regression Model for Flight Departures per 1,000♦

	Variables	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	P-Value	Collinearity Statistics Tolerance	Collinearity Statistics VIF
	Intercept (Constant)	100	32		3.12	0.002		
1	Traffic Shadow Effect	-18	8	-0.218	-2.39	0.019	0.876	1.142
2	Airline Hub	24	10	0.286	2.47	0.015	0.549	1.820
3	Age of Housing Stock	-1	0.0	-0.252	-2.82	0.006	0.921	1.085
4	Travel to Work Time, average	-6	1	-0.478	-4.09	<.0001	0.538	1.860
5	Per Capita Income	4	1	0.388	3.62	0.001	0.638	1.566

♦ For multiple regression models, dependent variables are normalized by MA population measured in thousands of people rather than per capita; this generates larger unstandardized coefficients (B) that should aid in model interpretation.

Flight Departures per 1,000 = 100 – 18 Shadow + 24 Hub – 1 Housing Age –
6 Travel to Work + 4 PCI

Average travel to work time has the largest absolute value for the standardized coefficient (Beta) indicating it has the largest affect on the model. The average travel time to work has an inverse relationship to flight departures per 1,000 residents; meaning that for each extra minute of time it takes the average member of the workforce to commute to work there will be fewer flight departures per 1,000. This inverse (negative) relationship is unexpected because, generally, highly agglomerated MAs have longer commute times. However, after careful analysis it appears that travel to work time is a surrogate for mega MAs that generally underperform when flight departures are normalized by the population, much like the PSMA sector independent variable in the previous model for enplanements per 1,000. Generally traffic congested MAs dominate flight departures when measured in absolute terms but not when flight departures are normalized by the MA population.

The independent variable that has the second largest Beta is per capita income (PCI). The model shows a direct relationship between flight departures per 1,000 and PCI; as per capita income goes up, so too should flight departures per 1,000, and vice versa. This variable is also in the model for enplanements per 1,000 showing some stability between the models.

A MA's status as an airline hub has the third largest Beta for flight departures per 1,000. A MA can expect to have more flight departures per 1,000 if an airline locates a major hub operation at that airport. For example, Raleigh-Durham, NC experienced a clear "boom-bust" cycle in flight departures over time based on the changing landscape of the airline industry. Raleigh-Durham's airport became a "mini hub" for American Airlines in 1987 rapidly growing to over 100 daily flights. The hub was never profitable and by 1995 American Airlines scaled back operations to just 35 daily flights (Debbage 1999). Raleigh-Durham is just one example of how MAs experience an ever changing level of flight departures based on the decisions of airlines.

The median age of housing stock has an inverse relationship to flight departures per 1,000. The absolute value of the Beta is the fourth largest in the model. The negative relationship shows that as the median home age goes up (gets older) there will be fewer flight departures per 1,000 and, conversely, the younger the median home age is the greater the flight departures per 1,000 for the MA. The median age of housing stock independent variable seems to be a surrogate for the traditional comparison of the Sunbelt and West versus the Rustbelt and North. This negative relationship might be considered similar to the other variables that describe mega MAs but median home age seems to have a more explicit regional context because the youngest homes are in the "New South" and West. There is just one Midwest or Northern MA (Springfield, MO) in the youngest MAs. The 18 MAs with the oldest median home age are all in the North/Midwest. Las Vegas has the newest housing stock (a median of only 13 years old) while Buffalo, NY has the oldest (a median of 53 years old).

The traffic shadow effect has an inverse relationship to flight departures per 1,000 meaning there is a negative impact for each MA with a small/medium FAA hub that is within 100 miles or shares a border with a MA that has large FAA hub. The rationale for this independent variable in this model is generally supported by the literature and real-world observations; Fuellhart (2007) specifically looks at the traffic shadow effect (i.e., market leakage) of Harrisburg International Airport to Baltimore International Airport. The traffic shadow independent variable is also in the enplanements per 1,000 model showing some stability of independent variables between the two models; the two models share three independent variables (traffic shadow effect, PCI, and airline hub status).

4.4.3: Market Originations Model

A passenger is considered an origination if the passenger starts an itinerary from the MA's market while not counting transfers at other MAs. The market origination variable does not account for 100% of all passengers, rather it is based on a 10% sample of all tickets. Only this survey data exists for any origination data. Specific assertions like a certain percentage increase for one independent variable could cause a specific increase of the dependent variable are more difficult due to the nature of this sample data, but general assertions regarding the positive or negative effects of an independent variable are possible. Despite its shortcomings, market origination data differs significantly enough with the other two dependent variables that its use in research and planning should not be dismissed.

The forward, backward, and stepwise selection procedures all selected the same five variable model. This five variable model has balance between levels of collinearity, fit, and significance so it is used, unchanged, as the model for market originations per 1,000 (Appendix D)

The five variable model for market originations per 1,000 yielded an R-square of 0.54 (Table 4.4.3). The independent variables are significant at the 0.02 level or better and multicollinearity is low as indicated by the VIFs well below three.

Table 4.4.3: Multiple Regression Model for Market Originations per 1,000♦

	Variables	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	P-Value	Collinearity Statistics Tolerance	Collinearity Statistics VIF
	Intercept (Constant)	-76	83.2		-0.91	0.3655		
1	Traffic Shadow Effect	-75	23.1	-0.233	-3.25	0.0016	0.915	1.0929
2	Age of Housing Stock	-3	1.2	-0.185	-2.49	0.0143	0.855	1.1697
3	Per Capita Income	15	3.2	0.377	4.57	<.0001	0.692	1.4446
4	Total Accommodation Employees	4	0.5	0.652	7.42	<.0001	0.609	1.641
5	PSMA sector, total Employees	-0.4	0.07	-0.510	-5.15	<.0001	0.479	2.0867

♦ For multiple regression models, dependent variables are normalized by MA population measured in thousands of people rather than per capita; this generates larger unstandardized coefficients (B) that should aid in model interpretation.

Market Originations per 1,000 = - 76 – 75 Shadow – 3 Housing Age +
4 PCI – 0.4 PSMA

Metropolitan Areas in a traffic shadow generate 75 fewer market originations per 1,000 residents and an additional year older for the metro's housing stock will generate three (3) fewer market originations per 1,000. MAs that grow per capita income by $1,000 will generate an additional 15 market originations per 1,000 residents. An additional 1,000 accommodation jobs will generate four (4) additional market originations per 1,000 and an additional 1,000 jobs in PSMA will generate 0.4 fewer passengers per 1,000 residents.

The independent variable total accommodation employees has the largest standardized coefficient (Beta) for market originations per 1,000. The direct relationship indicates that as the number of employees in the accommodation sector (NAICS 721) increases so do market originations per 1,000. The total accommodation employees independent variable was also in the enplanements per 1,000 regression model indicating some stability between these two models and the overall strength of total accommodation employees as an explanatory variable. If a person flies to a tourist destination, generally they fly home via a round trip ticket thus generating a market origination for the tourist destination MA. Four out the top five MAs in the rankings for market originations (Table 4.3) are tourist destinations proving the strength of this predictor variable.

The second largest absolute value of Beta is the total PSMA sector employees independent variable. Like in the earlier model for enplanements per 1,000 residents, the total employees in the PSMA sector has an inverse relationship to market originations per 1,000. As market originations go up then there are fewer employees in the PSMA sector, and vice versa. As with the enplanements per 1,000 model, the PSMA sector independent variable is a surrogate for mega MAs that generally underperform when the airport activity statistic is normalized by the population.

The third largest Beta is per capita income (PCI). Like with each dependent variable model, there is a direct relationship between market originations per 1,000 and PCI; meaning as market originations increase so does PCI, and vice versa. The PCI is one of two independent variables that are in all three of the regression models indicating some stability for the three models and the overall power of PCI as a predictor variable.

The fourth largest Beta is the traffic shadow effect. The inverse relationship between the traffic shadow effect and market originations per 1,000 residents means that a MA with a small/medium FAA hub in a traffic shadow of a large FAA hub MA will have fewer market originations. The traffic shadow effect is the second of two independent variables that are in all three regressions.

The fifth largest Beta is median age of housing stock. There is an inverse relationship between median age of housing stock of a MA and its market originations per 1,000. As indicated earlier when this variable was in the flight departures per 1,000 model, this variable captures the rise of the Sunbelt/West and fall of the Rustbelt/North. The North and the Rustbelt have large totals of market originations but generally underperform when normalized by the population, while the so called “New South” or Sunbelt and the West are generally overperforming. As stated earlier, with one exception the 50 MAs with the youngest median age of housing stock are all in warm, southern and/or western markets and, conversely, the 18 MAs with the oldest housing stock are all in the Northeast/Midwest.

4.5: Comparison of Regression Models

Each of the three dependent variable models are unique but share some interesting commonalities among the predictor variables (Table 4.5). Some predictor variables are consistently selected and significant through all three models while others are shared in only two models. Only one predictor variable (travel to work time) is unique to just one model. These commonalities suggest a reasonable level of stability between the three models.

Table 4.5: Model Comparison for Three Dependent Variable Models

		Enplanement per 1,000♦			Flight Departures per 1,000 ♦			Market Originations per 1,000♦		
		Unstandardized Coefficient (B)		Beta	Unstandardized Coefficient (B)		Beta	Unstandardized Coefficient (B)		Beta
1	Traffic Shadow Effect	-1,074	*	-0.2	-18	**	-0.22	-75	*	-0.23
2	Right to Work State									
3	Airline Hub in MA	2,183	*	0.45	24	**	0.286			
4	Travel to Work Time				-6	*	-0.48			
5	Per Capita Income	165	*	0.29	4	*	0.388	15	*	0.38
6	Unemployment, Percentage of Workforce**									
7	Professional, Scientific, Managerial, and Administrative (PSMA), total	-6	*	-0.6				-0.4	*	-0.51
8	Population growth									
9	Accommodation Employees	42	*	0.47				4	*	0.65
10	Accommodation Employees as percentage of workforce									
11	International Passenger Arrivals									
12	Median Age of Housing Stock				-1	*	-0.25	-3	**	-0.19
13	Bachelor Degree									
	Total Variables	5			5			5		
	R-Square	0.5583	*		0.2807	*		0.5387	*	

* P-Value < 0.01

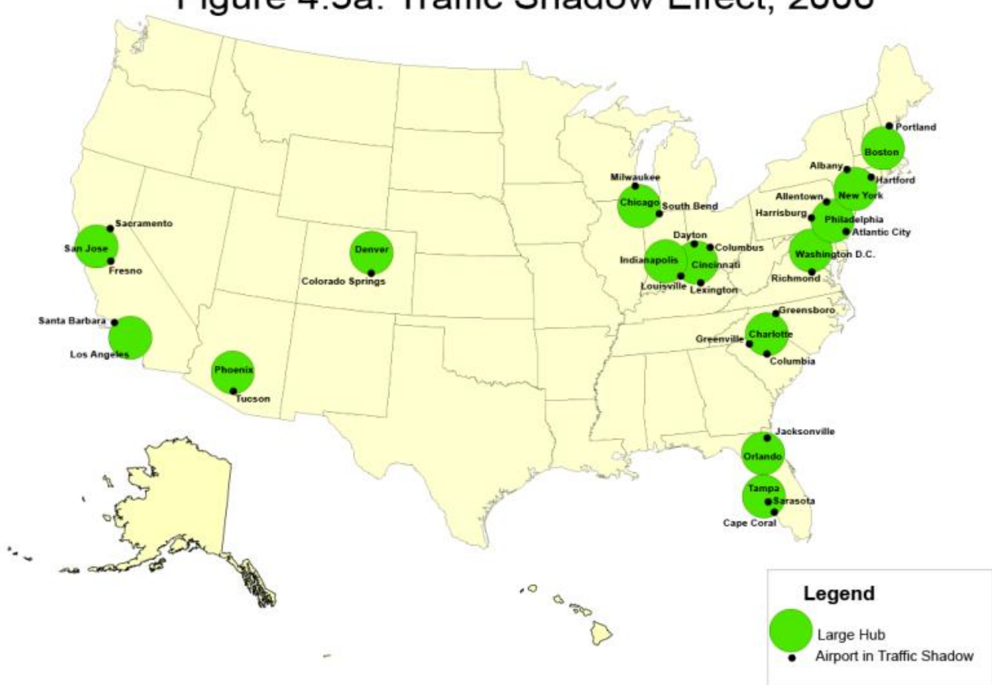
** P-Value < 0.02

(shaded) Denotes Independent Variable in all three models.

♦For multiple regression models, dependent variables are normalized by MA population measured in thousands of people rather than per capita; this generates larger unstandardized coefficients (B) that should aid in model interpretation.

The first predictor variable that is consistent through all three regression models is the traffic shadow effect. Figure 4.5a shows all the MAs that are within 100 miles or share a border with a MA that has a large FAA hub. The traffic shadow effect represents the geographic proximity and market leakage a small/medium FAA hub MA has if it is located near a MA with a large FAA hub. When a consumer is allowed a choice of where to start a trip on the air transportation network, the many advantages that a large FAA hub provides can influence the smaller market consumer to choose the larger MA for reasons including lower fare prices, schedule convenience, desirable connections, the presence of a low cost carrier (e.g., Southwest Airlines), and an assortment of other reasons. A MA can try to overcome this unchangeable

Figure 4.5a: Traffic Shadow Effect, 2006

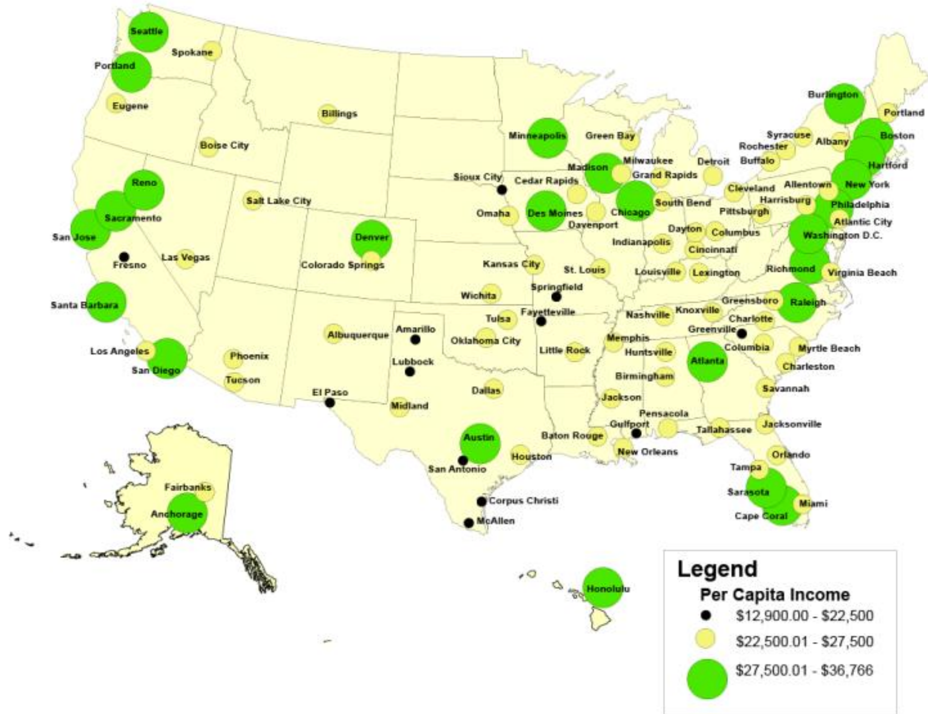


misfortune of geographic proximity by becoming a large FAA hub or hope the large FAA hub in the nearby MA contracts.

The second predictor variable that is consistent through all three regression models is per capita income (Figure 4.5b). Figure 4.5b shows how many high PCI MAs are in the “BosWash” megalopolis but also in smaller MAs that have airline hubs, affluent residents, and/or tourist destinations. PCI really captures a MA’s propensity to fly: the higher the PCI, the more likely that enplanements per 1,000, flight departures per 1,000, and market originations per 1,000 will increase. The presence of this predictor variable in all three models indicates that specific industrial sector make-up is less important than the overall wealth of the populace. A MA might have higher than average PCI due to many different and cumulative reasons, for example a robust new economy, a major tourist destination, and/or simply a large concentration of affluent retirees. The stability of the PCI and traffic shadow effect predictor variables across all three regression models indicates that they apply across the whole U.S. air passenger transportation network.

Airline hub status is the variable most directly linked to the geography of the U.S. air transportation network and specifically the airlines. However, the airline hub status independent variable is in both the enplanements per 1,000 and flight departures per 1,000 models, but not in the market originations per 1,000 model. Unlike enplanements and flight departures, the market originations variable deemphasizes airline hubs since it does not count connecting passengers. The per capita income map (Figure 4.5) indicates that some MAs with airline hubs have high per capita income (e.g., Atlanta, Denver) while others do not (e.g., Charlotte, Dallas). An airline hub alone will not yield a high PCI for the MA; further economic development is needed to fully leverage the competitive advantage of an airline hub.

Figure 4.5b: Per Capita Income, 2006



Another type of independent variable that is consistent across all three models are the independent variables that appear to act as a surrogate representing mega MAs that underperform when the airport activity statistic is normalized by the population. The total number of workers in the professional, scientific, management, and administrative sector (PSMA) is the surrogate independent variable for mega MAs in the enplanements per 1,000 and market originations per 1,000 models while average travel to work time appears to be the surrogate in the flight departures per 1,000 model; both of these independent variables have an inverse relationship to the dependent variables.

By contrast, the total accommodation employees independent variable is in the enplanements per 1,000 and market originations per 1,000 models. It is interesting that this independent variable is not in the flight departures per 1,000 model despite two major tourist destinations being in the top ten rankings (Table 4.2). The presence of this variable in the two passenger-based dependent variable models illustrates the importance of tourism has on the air transportation industry. The accommodation employees as a percentage of the workforce was not selected because, it seems, a MA needs a certain critical mass of accommodation employees (i.e., tourism industry) to generate enplanements and market originations.

The importance of the median age of housing stock variable illustrates a critical aspect of the U.S. and the air transportation network. The rise of the "New South" and the West is clearly evident in this predictor variable. The Southern and Western states have generally benefitted from the internal migration from the Northeast and Midwest and the accompanying economic development that resulted. The MAs with the oldest housing stock are clearly clustered in the Northeast and Midwest regions while MAs with the youngest median age of housing stock are clustered in the West and South; the dichotomy is striking. Arguably, this predictor variable shows the rise of the West and South in the post airline deregulation era.

In the end, the strength of each model is measured by the amount of variance that the model explains (i.e., R-square) and is shown in table 4.5b. The enplanements per 1,000 and market originations per 1,000 models both explain over 50% of the variance with five variables; the difference between these two passenger based models is less than two percent. It is interesting that these two different dependent variables measure different aspects of the geographic distribution of airport activity in the U.S. but still share four of five predictor variables and both have high R-Square values.

CHAPTER V

CONCLUSION

Airports and the airline industry are a key component of the national economy, in part, because air transportation fundamentally shapes the spatial hierarchy of metropolitan economies and related connectivity levels. Airports can be an important part of a region's competitive advantage especially regarding the way in which a metropolitan area grows its knowledge-based economy given the crucial importance of face-to-face contact and business travel.

Although a significant amount of research has been conducted that attempts to assess the key role of airports for metropolitan areas, little research has been conducted that simultaneously assesses the significance of different measures of airport activity rates. Key measures of airports activity includes quantifying the volume of enplanements (boarding passengers), measuring the number of flight departures as a measure of connectivity levels, and analyzing market originations. By comparing the differential performance of each of these airport activity rates, it becomes possible to acquire a more nuanced understanding of how these variables might vary spatially and which predictor variables best explain this spatial variation.

In this thesis, the three airport activity measures – enplanements, flight departures, and market originations– were normalized by the MA population to yield a productivity rate that allowed for direct comparisons between large and small metropolitan markets. By ranking the metropolitan areas for each of these dependent variables, it becomes possible to better understand the geography of air transportation by metropolitan area.

One key MA characteristic in explaining the spatial variation of airport activity rates by metropolitan area is the tourism industry. Major tourism-dominated metropolitan areas like Las Vegas and Honolulu featured prominently in all three measures of airport activity rates although tourism only vaults metropolitan areas to a high ranking if the tourist accommodation sector generated a large number of jobs, suggesting that airport activity rates are positively impacted only when the tourist industry reaches a certain size. Another important factor in shaping airport activity rates is the presence of a major airline-based hub-and-spoke network which tended to elevate airport activity rates. Major metropolitan areas that hosted substantial airline hub-and-spoke operations like Charlotte and Denver tended to over-perform regarding airport activity rates. The positive effect of an airline hub on a MA was expected but only for the enplanements per capita; but it was evident, in some respect, in all three MA rankings of the dependent variables.

The regression models for enplanements, market originations, and flight departures dependent variables normalized by the metropolitan area population suggest an elevated level of stability in the selection of the predictor variables even though each dependent variable captured different aspects of airport traffic; of the thirteen total independent variables, seven were used to make all three of the five-variable models. Only two predictor variables, per capita income and the traffic shadow effect, featured prominently in all three regression models. Disproportionately high per capita income levels appear to indicate that wealthier MAs generate higher propensities to fly. By contrast, the traffic shadow effect is an explicitly geographic predictor variable that reveals the complex relationships that exist between MAs in the urban hierarchy. If a smaller metropolitan area is proximate to a larger metropolitan market, it appears that this can negatively impact the smaller hub market as would-be passengers can choose the metropolitan areas with the larger FAA hub that likely offers more frequent service to more destinations.

Metropolitan areas that dominate airport activity measures in the absolute (e.g., New York City and Washington D.C.) underperform when the airport activity measure is normalized by the population. Much of the explanation for this surprising anomaly lies with the large size of many combined statistical areas (CSAs) relative to the small number of airports that serve specific CSAs. For example, the New York City CSA has three major airports and several smaller airports, but the large total population of the CSA (i.e., 22 million) means that in some respects the New York City metropolitan areas is underserved given the large catchment area. Consequently, it appears that several independent variables that are normally considered strong positive indicators of airport activity are instead inversely related to enplanement, flight departures, and market origination per capita measures. These "surrogate" variables include the total number of workers in the professional, scientific, management, and administrative sector (PSMA) and average travel to work time; these variables tend to be high in larger CSA markets that also underperform when airport activity is normalized by the metropolitan area population.

Overall, the most robust dependent variable appeared to be enplanements per capita because the models five variables accounted for the most variance. Part of the reasoning behind this finding may be due to the ability of enplanements to effectively capture the importance of airline hubs since it measures all boarding passengers on every flight segment and so captures connecting passengers. The market originations variable does not capture connecting passengers since it only measures where passengers initiate a departure. By contrast, the flight departure variable is unable to discriminate between large and small aircraft and, in this sense, may be a more blunt measure of airport activity.

There are several policy implications based on this research. Planners and practitioners should look at means to grow wealth of the MA’s population (i.e., raise the PCI). For this, a long view is needed rather than a focus on short-term gains. The leadership of a MA (elected, business, and social) need to focus on how best to leverage the MA's airport(s), if at all, to build long-term wealth for its populace. Further, economic development based mostly on airport development/expansion for a MA in a traffic shadow of a large FAA hub is likely to underperform or potentially even fail. Rather, MAs in a traffic shadow should focus on broadening their catchment area for their airport(s). Additionally, large market metropolitan areas (e.g., New York City, Los Angeles) need more airport capacity due to their considerable underperformance in each per capita airport activity measure.

Additional areas of research might include a more explicit focus on air freight in addition to the geography of air passengers. It is clear that air freight is a major influence on the shape of the airline network particularly when analyzing flight departures in places like Memphis which host the FedEx super hub. Another area of research might include analyzing how the presence of a low-cost air carrier like Southwest Airlines or JetBlue might distort or influence the regression model findings particularly as it relates to the geography of airfares and its impact on airport activity rates. Finally, another area of research might include a more refined catchment area for each airport region that would be more nuanced than the metropolitan area geography used in this thesis.

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APPENDIX A

104 Metropolitan Areas' Airport Activity Statistics rank ordered by Enplaned Passengers Per Capita, 2006

No Fill Denotes CSA | Red Fill Denotes MSA

	Metropolitan Area	Enplanements per Capita	Flight Departures per Capita	Market Originations per Capita
1	Las Vegas-Paradise-Pahrump, NV Combined Statistical Area	11.690	0.114	0.917
2	Honolulu, HI Metropolitan Statistical Area	9.276	0.103	0.634
3	Orlando-Deltona-Daytona Beach, FL Combined Statistical Area	7.722	0.075	0.678
4	Denver-Aurora-Boulder, CO Combined Statistical Area	7.678	0.097	0.383
5	Atlanta-Sandy Springs-Gainesville, GA-AL Combined Statistical Area	7.445	0.085	0.241
6	Charlotte-Gastonia-Salisbury, NC-SC Combined Statistical Area	6.697	0.101	0.188
7	Cape Coral-Fort Myers, FL Metropolitan Statistical Area	6.402	0.064	0.624
8	Salt Lake City-Ogden-Clearfield, UT Combined Statistical Area	6.298	0.096	0.315
9	Anchorage, AK Metropolitan Statistical Area	6.103	0.223	0.402
10	Reno-Sparks-Fernley, NV Combined Statistical Area	5.403	0.068	0.504
11	Phoenix-Mesa-Scottsdale, AZ Metropolitan Statistical Area	5.042	0.058	0.301
12	Dallas-Fort Worth, TX Combined Statistical Area	4.999	0.061	0.215
13	Minneapolis-St. Paul-St. Cloud, MN-WI Combined Statistical Area	4.892	0.061	0.215
14	Fairbanks, AK Metropolitan Statistical Area	4.868	0.250	0.377
15	Miami-Fort Lauderdale-Pompano Beach, FL Metropolitan Statistical Area	4.759	0.051	0.306
16	Chicago-Naperville-Michigan City, IL-IN-WI Combined Statistical Area	4.468	0.056	0.216
17	Memphis, TN-MS-AR Metropolitan Statistical Area	4.321	0.131	0.133
18	Houston-Baytown-Huntsville, TX Combined Statistical Area	4.245	0.060	0.177

APPENDIX A (Continued 2 of 6)

	Metropolitan Area	Enplanements per Capita	Flight Departures per Capita	Market Originations per Capita
19	Albuquerque, NM Metropolitan Statistical Area	3.885	0.057	0.336
20	Seattle-Tacoma-Olympia, WA Combined Statistical Area	3.704	0.046	0.259
21	Cincinnati-Middletown-Wilmington, OH-KY-IN Combined Statistical Area	3.700	0.075	0.098
22	San Jose-San Francisco-Oakland, CA Combined Statistical Area	3.610	0.041	0.277
23	Spokane, WA Metropolitan Statistical Area	3.594	0.059	0.340
24	Washington-Baltimore-Northern Virginia, DC-MD-VA-WV Combined Statistical Area	3.493	0.049	0.241
25	Tampa-St. Petersburg-Clearwater, FL Metropolitan Statistical Area	3.341	0.036	0.303
26	Detroit-Warren-Flint, MI Combined Statistical Area	3.295	0.044	0.144
27	Burlington-South Burlington, VT Metropolitan Statistical Area	3.287	0.078	0.292
28	Portland-Vancouver-Beaverton, OR-WA Metropolitan Statistical Area	3.188	0.046	0.257
29	Nashville-Davidson--Murfreesboro--Columbia, TN Combined Statistical Area	3.104	0.046	0.256
30	Raleigh-Durham-Cary, NC Combined Statistical Area	2.982	0.049	0.258
31	San Diego-Carlsbad-San Marcos, CA Metropolitan Statistical Area	2.930	0.033	0.269
32	New Orleans-Metairie-Bogalusa, LA Combined Statistical Area	2.921	0.034	0.270
33	Boise City-Nampa, ID Metropolitan Statistical Area	2.916	0.054	0.259
34	Billings, MT Metropolitan Statistical Area	2.719	0.081	0.244
35	Kansas City-Overland Park-Kansas City, MO-KS Combined Statistical Area	2.681	0.038	0.234
36	Austin-Round Rock, TX Metropolitan Statistical Area	2.604	0.034	0.234

APPENDIX A (Continued 3 of 6)

	Metropolitan Area	Enplanements per Capita	Flight Departures per Capita	Market Originations per Capita
37	Hartford-West Hartford-Willimantic, CT Combined Statistical Area	2.586	0.036	0.245
38	St. Louis-St. Charles-Farmington, MO-IL Combined Statistical Area	2.455	0.043	0.171
39	Omaha-Council Bluffs-Fremont, NE-IA Combined Statistical Area	2.417	0.040	0.224
40	Savannah-Hinesville-Fort Stewart, GA Combined Statistical Area	2.400	0.039	0.219
41	Sioux City-Vermillion, IA-NE-SD Combined Statistical Area	2.364	0.067	0.217
42	Philadelphia-Camden-Vineland, PA-NJ-DE-MD Combined Statistical Area	2.358	0.036	0.137
43	Jacksonville, FL Metropolitan Statistical Area	2.333	0.032	0.215
44	Sacramento--Arden-Arcade--Yuba City, CA-NV Combined Statistical Area	2.323	0.027	0.221
45	Myrtle Beach-Conway-Georgetown, SC Combined Statistical Area	2.312	0.037	0.222
46	El Paso, TX Metropolitan Statistical Area	2.278	0.035	0.209
47	Boston-Worcester-Manchester, MA-RI-NH Combined Statistical Area	2.247	0.032	0.197
48	Tucson, AZ Metropolitan Statistical Area	2.184	0.028	0.207
49	Milwaukee-Racine-Waukesha, WI Combined Statistical Area	2.118	0.046	0.163
50	Cleveland-Akron-Elyria, OH Combined Statistical Area	2.106	0.044	0.151
51	Cedar Rapids, IA Metropolitan Statistical Area	2.069	0.058	0.179
52	Buffalo-Niagara-Cattaraugus, NY Combined Statistical Area	2.067	0.033	0.186
53	New York-Newark-Bridgeport, NY-NJ-CT-PA Combined Statistical Area	2.067	0.026	0.143
54	Los Angeles-Long Beach-Riverside, CA Combined Statistical Area	2.033	0.024	0.161

APPENDIX A (Continued 4 of 6)

	Metropolitan Area	Enplanements per Capita	Flight Departures per Capita	Market Originations per Capita
55	Indianapolis-Anderson-Columbus, IN Combined Statistical Area	2.013	0.041	0.169
56	Pittsburgh-New Castle, PA Combined Statistical Area	2.002	0.040	0.146
57	Lubbock-Levelland, TX Combined Statistical Area	1.986	0.042	0.193
58	San Antonio, TX Metropolitan Statistical Area	1.969	0.026	0.182
59	Corpus Christi-Kingsville, TX Combined Statistical Area	1.927	0.037	0.191
60	Midland-Odessa, TX Combined Statistical Area	1.881	0.036	0.188
61	Amarillo, TX Metropolitan Statistical Area	1.850	0.038	0.182
62	Pensacola-Ferry Pass-Brent, FL Metropolitan Statistical Area	1.835	0.037	0.152
63	Columbus-Marion-Chillicothe, OH Combined Statistical Area	1.700	0.031	0.148
64	Tulsa-Bartlesville, OK Combined Statistical Area	1.689	0.030	0.150
65	Atlantic City, NJ Metropolitan Statistical Area	1.683	0.019	0.132
66	Colorado Springs, CO Metropolitan Statistical Area	1.665	0.032	0.156
67	Des Moines-Newton-Pella, IA Combined Statistical Area	1.567	0.041	0.134
68	Charleston-North Charleston, SC Metropolitan Statistical Area	1.564	0.034	0.137
69	Syracuse-Auburn, NY Combined Statistical Area	1.543	0.035	0.136
70	Little Rock-North Little Rock-Pine Bluff, AR Combined Statistical Area	1.491	0.028	0.137
71	Green Bay, WI Metropolitan Statistical Area	1.482	0.036	0.135
72	Tallahassee, FL Metropolitan Statistical Area	1.464	0.042	0.094

APPENDIX A (Continued 5 of 6)

	Metropolitan Area	Enplanements per Capita	Flight Departures per Capita	Market Originations per Capita
73	Virginia Beach-Norfolk-Newport News, VA-NC Metropolitan Statistical Area	1.460	0.028	0.132
74	Oklahoma City-Shawnee, OK Combined Statistical Area	1.450	0.024	0.128
75	Richmond, VA Metropolitan Statistical Area	1.377	0.030	0.115
76	Louisville-Jefferson County--Elizabethtown-Scottsburg, KY-IN Combined Statistical Area	1.353	0.049	0.119
77	Fayetteville-Springdale-Rogers, AR-MO Metropolitan Statistical Area	1.350	0.037	0.117
78	Madison-Baraboo, WI Combined Statistical Area	1.336	0.029	0.116
79	Birmingham-Hoover-Cullman, AL Combined Statistical Area	1.314	0.021	0.120
80	Jackson-Yazoo City, MS Combined Statistical Area	1.305	0.027	0.121
81	Rochester-Batavia-Seneca Falls, NY Combined Statistical Area	1.251	0.028	0.110
82	Albany-Schenectady-Amsterdam, NY Combined Statistical Area	1.250	0.024	0.119
83	Dayton-Springfield-Greenville, OH Combined Statistical Area	1.214	0.026	0.110
84	Davenport-Moline-Rock Island, IA-IL Metropolitan Statistical Area	1.202	0.030	0.106
85	South Bend-Elkhart-Mishawaka, IN-MI Combined Statistical Area	1.188	0.035	0.106
86	Portland-Lewiston-South Portland, ME Combined Statistical Area	1.142	0.027	0.108
87	Wichita-Winfield, KS Combined Statistical Area	1.131	0.028	0.098
88	Santa Barbara-Santa Maria-Goleta, CA Metropolitan Statistical Area	1.084	0.040	0.100
89	Eugene-Springfield, OR Metropolitan Statistical Area	1.068	0.032	0.096
90	Huntsville-Decatur, AL Combined Statistical Area	1.065	0.029	0.092
91	Gulfport-Biloxi-Pascagoula, MS Combined Statistical Area	1.061	0.021	0.098

APPENDIX A (Continued 6 of 6)

	Metropolitan Area	Enplanements per Capita	Flight Departures per Capita	Market Originations per Capita
92	Springfield, MO Metropolitan Statistical Area	1.052	0.031	0.092
93	Sarasota-Bradenton-Punta Gorda, FL Combined Statistical Area	1.024	0.014	0.099
94	Harrisburg-Carlisle-Lebanon, PA Combined Statistical Area	0.875	0.028	0.078
95	Columbia-Newberry, SC Combined Statistical Area	0.855	0.028	0.075
96	Knoxville-Sevierville-La Follette, TN Combined Statistical Area	0.806	0.023	0.065
97	Lexington-Fayette--Frankfort--Richmond, KY Combined Statistical Area	0.781	0.022	0.065
98	Grand Rapids-Muskegon-Holland, MI Combined Statistical Area	0.761	0.017	0.067
99	Greensboro--Winston-Salem--High Point, NC Combined Statistical Area	0.715	0.019	0.059
100	Baton Rouge-Pierre Part, LA Combined Statistical Area	0.667	0.017	0.060
101	Greenville-Spartanburg-Anderson, SC Combined Statistical Area	0.628	0.018	0.052
102	Fresno-Madera, CA Combined Statistical Area	0.582	0.017	0.052
103	McAllen-Edinburg-Mission, TX Metropolitan Statistical Area	0.564	0.008	0.052
104	Allentown-Bethlehem-Easton, PA-NJ Metropolitan Statistical Area	0.486	0.018	0.043

Appendix B.

Federal Aviation Administration Hubs not used in analysis.

FAA Hub Not used	**Reason**
St. Thomas, V.I.	Not U.S. CSA/MSA
Saipan, Mariana Islands	Not U.S. CSA/MSA
San Juan, Puerto Rico	Not U.S. CSA/MSA
Guam	Not U.S. CSA/MSA
Kona, Hawaii	No CSA/MSA for Airport
Lihue, Hawaii	No CSA/MSA for Airport
Hilo, Hawaii	No CSA/MSA for Airport
Kahului, Hawaii	No CSA/MSA for Airport

Appendix C

Metropolitan Areas with Multiple Airports*

No Fill Denotes CSA | Red Fill Denotes MSA

Metropolitan Area Name (AIRPORT NAME - CODE)	FAA Hub (S, M, L)	Percent Enplanements for 2006*
Boston-Worcester-Manchester, MA-RI-NH Combined Statistical Area		
(LOGAN INTERNATIONAL - BOS)	L	1.74
(MANCHESTER AIRPORT - MHT)	M	0.27
(THEODORE FRANCIS GREEN - PVD)	M	0.37
	MA Total	**2.38**
Chicago-Naperville-Michigan City, IL-IN-WI Combined Statistical Area		
(CHICAGO MIDWAY AIRPORT - MDW)	L	1.27
(O HARE AIRPORT - ORD)	L	4.91
	MA Total	**6.18**
Cleveland-Akron-Elyria, OH Combined Statistical Area		
(HOPKINS INTERNATIONAL AIRPORT - CLE)	M	0.77
(AKRON/CANTON REGIONAL - CAK)	S	0.10
	MA Total	**0.87**
Corpus Christi-Kingsville, TX Combined Statistical Area		
(CORPUS CHRISTI INTERNATIONAL - CRP)	S	0.06
(HARLINGEN INDUSTRIAL AIRPRK - HRL)	S	0.06
	MA Total	**0.12**
Dallas-Fort Worth, TX Combined Statistical Area		
(DALLAS/FT WORTH INTL - DFW)	L	4.03
(DALLAS LOVE FIELD - DAL)	M	0.49
	MA Total	**4.52**
Detroit-Warren-Flint, MI Combined Statistical Area		
(DETROIT METRO WAYNE COUNTY - DTW)	L	2.46
(BISHOP - FNT)	S	0.08
	MA Total	**2.54**
Houston-Baytown-Huntsville, TX Combined Statistical Area		
(HOUSTON INTERCONTINENTAL - IAH)	L	2.82
(WILLIAM P HOBBY AIRPORT - HOU)	M	0.58
	MA Total	**3.40**
Las Vegas-Paradise-Pahrump, NV Combined Statistical Area		
(MC CARRAN INTERNATIONAL - LAS)	L	3.01
(NORTH AIR TERMINAL - VGT)	-	0.02
	MA Total	**3.03**

* Airport must have at least 0.01% enplanements to appear on table.

Appendix C (Continued, 2 of 2)

Metropolitan Area Name (AIRPORT NAME - CODE)	FAA Hub (S, M, L)	Percent Enplanements for 2006*
Los Angeles-Long Beach-Riverside, CA Combined Statistical Area		
(LOS ANGELES INTERNATIONAL AIRPORT - LAX)	L	3.29
(JOHN WAYNE INTERNATIONAL - SNA)	M	0.68
(ONTARIO INTERNATIONAL AIRPORT - ONT)	M	0.47
(BURBANK BOB HOPE AIRPORT - BUR)	M	0.40
(LONG BEACH DAUGHERTY FIELD - LGB)	S	0.19
(PALM SPRINGS MUNI - PSP)	S	0.10
	MA Total	**5.13**
Miami-Fort Lauderdale-Pompano Beach, FL Metropolitan Statistical Area		
(MIAMI INTERNATIONAL AIRPORT - MIA)	L	1.84
(FORT LAUDERDALE INTERNATIONAL - FLL)	L	1.37
(PALM BEACH INTERNATIONAL - PBI)	M	0.48
	MA Total	**3.69**
New York-Newark-Bridgeport, NY-NJ-CT-PA Combined Statistical Area		
(KENNEDY INTERNATIONAL AIRPORT - JFK)	L	2.14
(LA GUARDIA AIRPORT - LGA)	L	1.77
(NEWARK LIBERTY INTERNATIONAL - EWR)	L	2.31
(WESTCHESTER COUNTY - HPN)	S	0.07
(LONG ISLAND-MACARTHUR - ISP)	S	0.16
	MA Total	**6.45**
San Jose-San Francisco-Oakland, CA Combined Statistical Area		
(INTERNATIONAL AIRPORT - SFO)	L	1.98
(SAN JOSE INTL AIRPORT - SJC)	M	0.74
(METROPOLITAN OAKLAND INTL - OAK)	M	0.99
	MA Total	**3.71**
Seattle-Tacoma-Olympia, WA Combined Statistical Area		
(SEATTLE/TACOMA INTL. AIRPORT - SEA)	L	2.03
(LAKE UNION SPB - LKE)	-	0.01
	MA Total	**2.04**
Virginia Beach-Norfolk-Newport News, VA-NC Metropolitan Statistical Area		
(NORFOLK INTERNATIONAL - ORF)	M	0.26
(PATRICK HENRY INTERNATIONAL - PHF)	S	0.07
	MA Total	**0.33**
Washington-Baltimore-Northern Virginia, DC-MD-VA-WV Combined Statistical Area		
(DULLES INTERNATIONAL AIRPORT - IAD)	L	1.38
(WASHINGTON NATIONAL AIRPORT - DCA)	L	1.26
(BALTIMORE/WASHINGTON INTL - BWI)	L	1.43
	MA Total	**4.07**

* Airport must have at least 0.01% enplanements to appear on table.

Appendix D
Dependent Variable Collinearity Diagnostics

Collinearity Diagnostics for Enplanements per Capita

			Proportion of Variation					
Dimension	Eigenvalue	Condition Index	Intercept (Constant)	Airline Hub	Traffic Shadow Effect	Per Capita Income	PSMA sector, total Employees	Total Accommodation Employees
1	3.576	1.000	0.001	0.017	0.008	0.001	0.017	0.022
2	1.338	1.635	0.001	0.047	0.225	0.001	0.025	0.031
3	0.489	2.704	0.006	0.002	0.627	0.004	0.019	0.138
4	0.329	3.296	0.001	0.170	0.071	0.000	0.218	0.808
5	0.261	3.699	0.000	0.735	0.032	0.000	0.610	0.001
6	0.007	23.281	0.992	0.028	0.037	0.994	0.111	0.000

Collinearity Diagnostics for Flight Departures Per Capita

			Proportion of Variation					
Dimension	Eigenvalue	Condition Index	Intercept (Constant)	Traffic Shadow Effect	Airline Hub	Age of Housing Stock	Travel to Work Time, average	Per Capita Income
1	4.458	1.000	0.000	0.010	0.007	0.003	0.000	0.001
2	1.004	2.107	0.000	0.334	0.215	0.000	0.000	0.000
3	0.471	3.077	0.001	0.623	0.390	0.008	0.000	0.001
4	0.053	9.153	0.012	0.001	0.054	0.885	0.027	0.012
5	0.008	23.013	0.098	0.019	0.017	0.035	0.234	0.976
6	0.006	28.316	0.889	0.013	0.318	0.068	0.738	0.011

Collinearity Diagnostics for Market Originations per Capita

			Proportion of Variation					
Dimension	Eigenvalue	Condition Index	Intercept (Constant)	Traffic Shadow Effect	Age of Housing Stock	Per Capita Income	Total Accommodation Employees	PSMA sector, total Employees
1	3.940	1.000	0.001	0.012	0.003	0.001	0.013	0.011
2	1.144	1.856	0.000	0.226	0.001	0.000	0.119	0.085
3	0.553	2.669	0.002	0.697	0.010	0.001	0.158	0.020
4	0.315	3.539	0.001	0.035	0.000	0.000	0.585	0.627
5	0.041	9.760	0.040	0.000	0.956	0.061	0.125	0.050
6	0.007	24.401	0.956	0.029	0.029	0.937	0.000	0.207